LUMBER AND ITS USES

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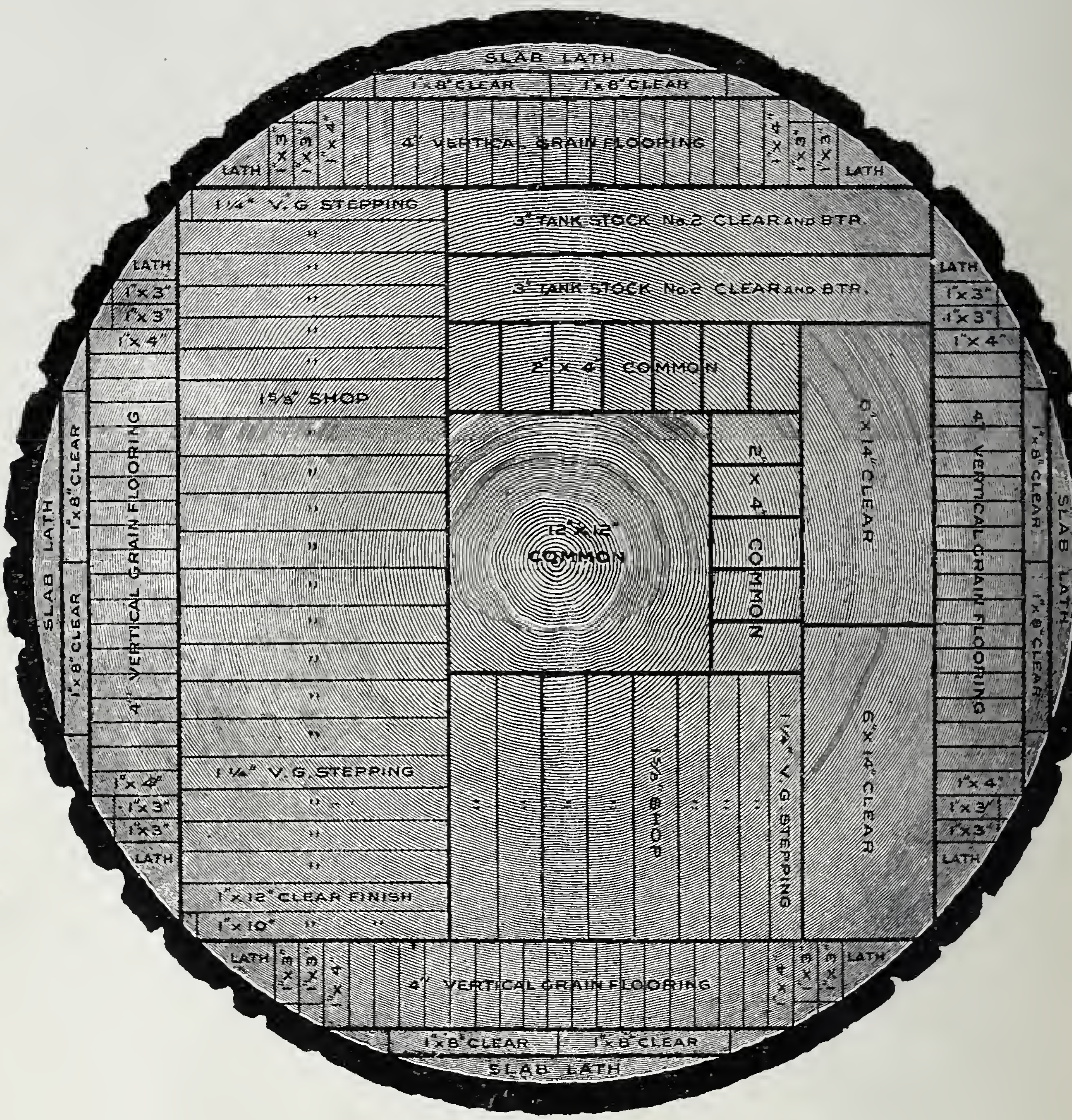

Lumber Products that may be obtained from a Douglas Fir Log.

LUMBER

AND ITS USES

BY

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PREFACE

There is no last word about lumber or the lumber industry. The uses of wood are constantly changing and becoming more diversified. Cellulose, the principal constituent of wood, is a complex substance, whose composition is still a subject of scientific investigation. Improvements and economies in wood utilization will continue to take place as timber becomes more valuable. Substitutes are many and varied, but there will always be need for all the wood fiber that the forests of the world can permanently produce.

"Lumber and Its Uses" attempts to tell in simple, non-technical fashion about the properties and uses of the principal American species which are manufactured into lumber. There are many other forms of wood utilization which are outside the scope of this volume. It could not have been written without the information developed by the technical and statistical studies of the United States Forest Service during the past twenty years. Grateful acknowledgment is made to the several members of the Service who have been of every possible assistance in the undertaking and also to officers of lumber associations and others who have supplied material for inclusion in the present edition.

R. S. K.

New York City.
December, 1923.

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CHAPTER I

THE STRUCTURE OF WOOD

Few of either the producers or the users of forest products—and the latter class includes each one of us—have any conception of the real structure of the material with which they deal. The botanist distinguishes one tree from another by differences in foliage, flowers, fruits, and bark; the technologist, by differences in the structure and arrangement of cells which may be visible only through a high-powered microscope; the carpenter, by characteristics of texture and weight learned in the working of wood; the woodsman, by general notions of appearance; and the ordinary user, by any combination of these methods that may have impressed him in the course of his experience. While the botanist and the mircroscopist use scientifically exact means of determining species of trees and kinds of wood, the lumberman, the cabinet-maker, and the man in the street use methods which, while unscientific and even impossible to describe, nevertheless often suffice for their own particular needs.

Wood is bought, sold, and used with far less knowledge of its composition, strength, stiffness, density, and other qualities than is any other substance that enters largely into our daily life. A steel rail is made according to a formula prepared by the metallurgist; there are standard mixtures for cement and concrete; the physical properties of metals and stone are accurately known; but even the best grading rules

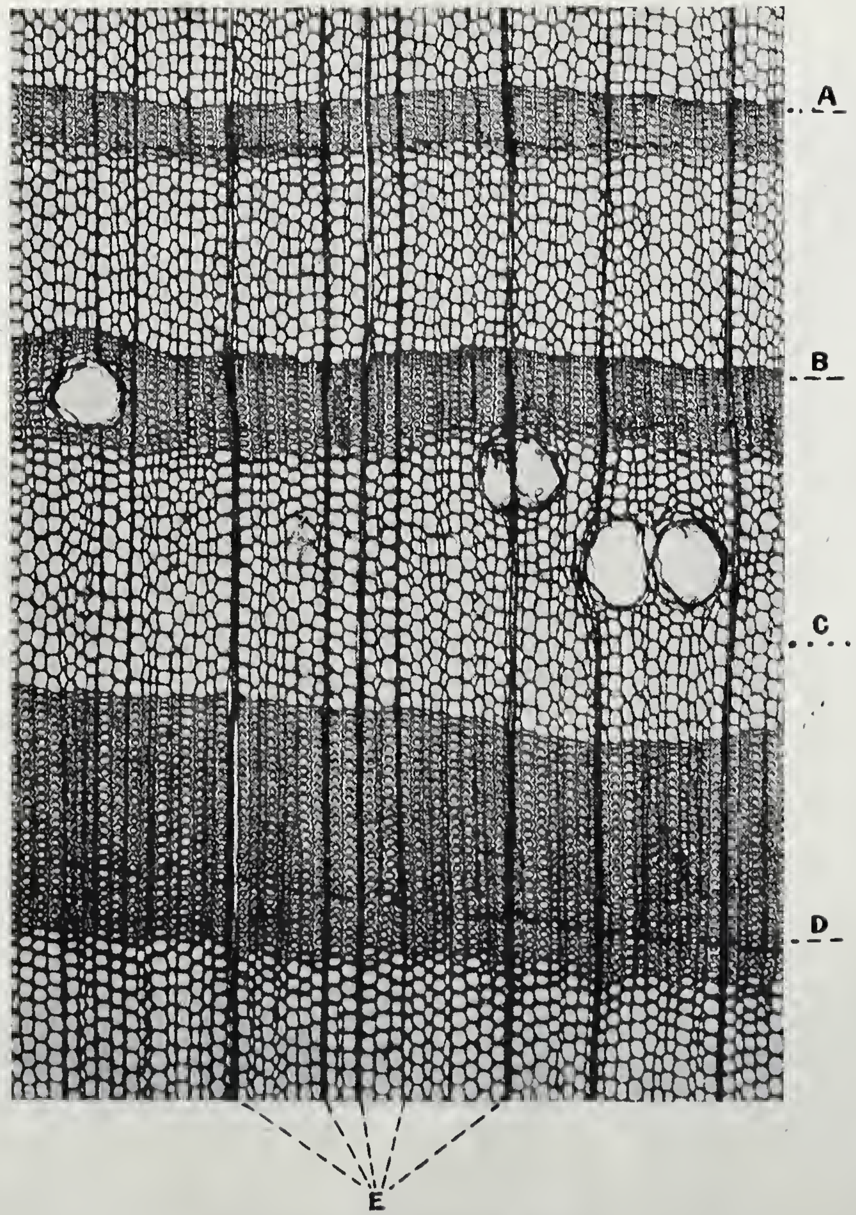


Fig. 1.—Longleaf Pine.

A non-porous wood. Large openings are resin ducts. B to A—one year's growth; B—Thick-walled summer wood cells: C—Thin-walled springwood cells; D—Summerwood of previous year; E—Medullary rays.

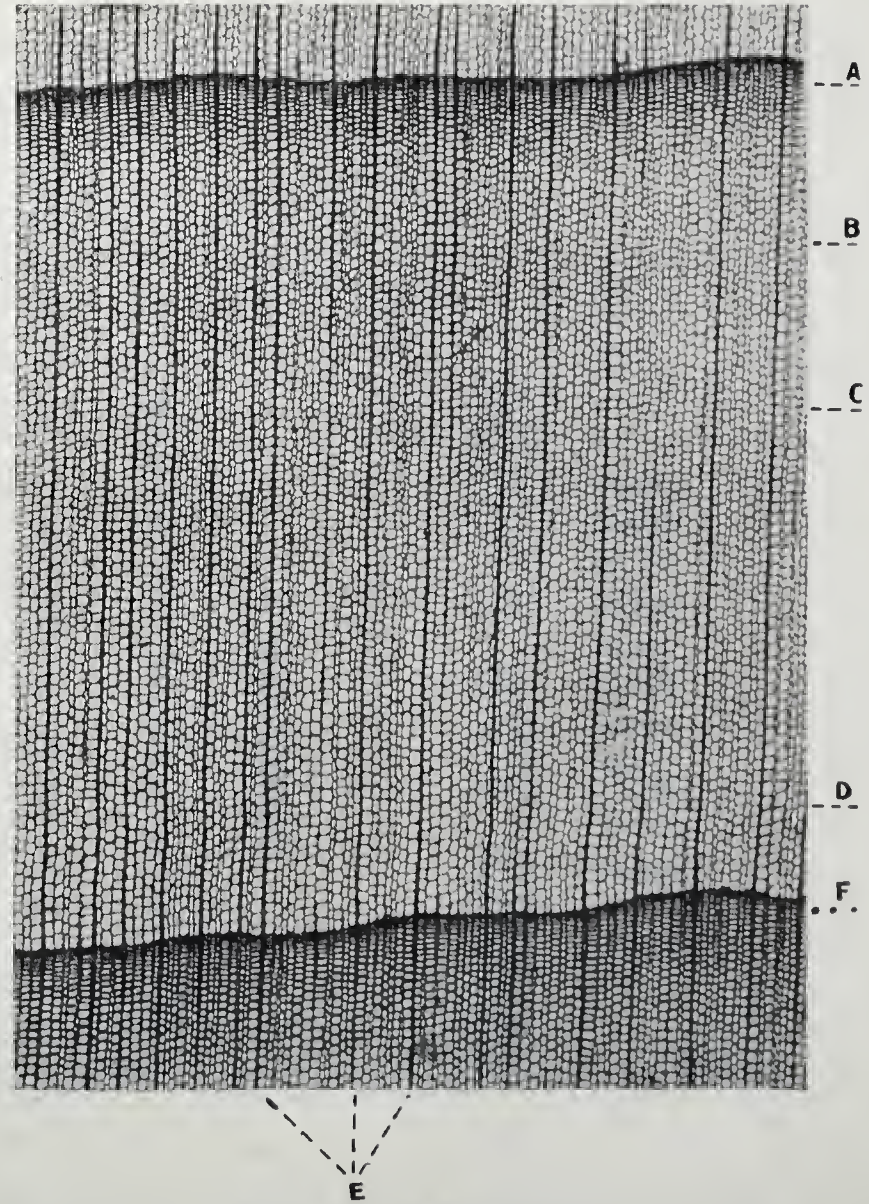


Fig. 2.—Balsam Fir.

A non-porous wood. F to A—One year's growth; B—Summerwood; C—Cells thin-walled and almost uniform in size; D—Springwood; E—Medullary rays.

COMPARISON OF TWO NON-POROUS WOODS

of the manufacturers are only approximations to the actual values of the different classes of lumber. To a large extent this is an unavoidable condition. A tree is not made according to any chemical or mechanical formula. It is the product of soil, moisture, and sunshine in constantly varying combinations. Buffeted by storms and subjected to extremes of heat and cold, drouth, and flood for a century or more, each year's growth is different from that which precedes or follows; and the resulting mass of wood is a highly complex substance of which we know far too little.

But the problems of modern construction and utilization demand that our knowledge of wood be increased in scope and accuracy. Therefore the timber-testing engineer, with his ponderous machines, determines the strength, stiffness, and elasticity of beams of a specified size and kind; the timber-treating expert, with cylinders and pressure pumps, finds out the best means of impregnating wood with creosote, zinc chloride, and other decay-preventing substances; the pulp-maker cooks and grinds different woods to get the best kind of pulp for paper; the chemist puts wood into his retort, and gets alcohol, turpentine, acid, and many other products; but all of these problems go back to the fundamental one of the structure of the wood itself.

Porous and Non-Porous Woods.—The unit of woody structure, as of all vegetable and animal growth, is the cell; and the scientific classification of woods is based upon the properties and combinations of these ultimate units. When cross-sections of certain woods are examined, they are seen to contain relatively large, irregularly placed openings called "pores." Other woods, even under the microscope, show no such openings. A natural, fundamental division, therefore, is into "porous" and "non-porous" woods. Of porous woods, the common hardwoods are familiar examples; while the pines, firs, spruces, cedars, etc., are non-porous. Again, the porous woods are divided into two classes according to the arrangement of the pores in the yearly ring of wood. In some woods, very large pores develop early in the season; while only small pores or none at all appear later, so that a cross-section of such a wood shows, even to the naked eye, concentric circles of openings. These woods are called "ring-porous" woods.

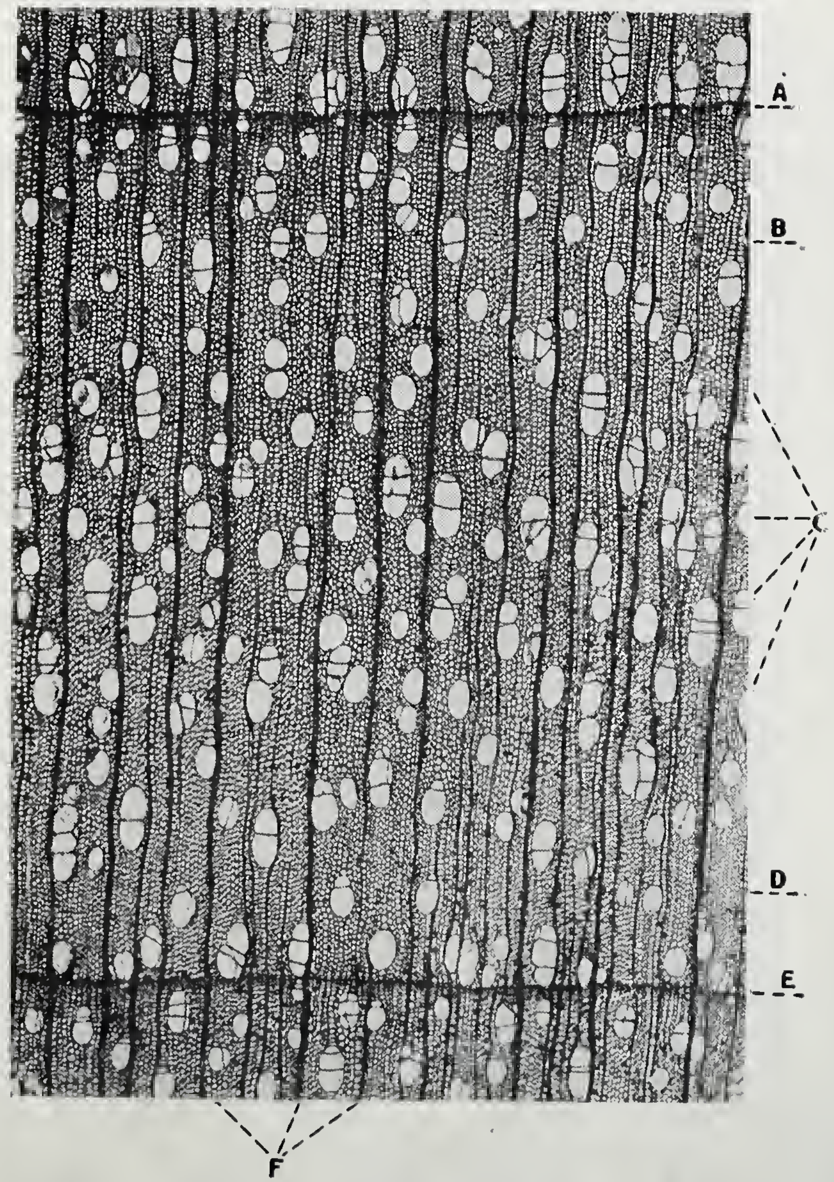


Fig. 3.—Yellow Birch.

A diffuse-porous wood. E to A—One year's growth; B—Summerwood; C—Pores; D—Springwood; F—Medullary rays.

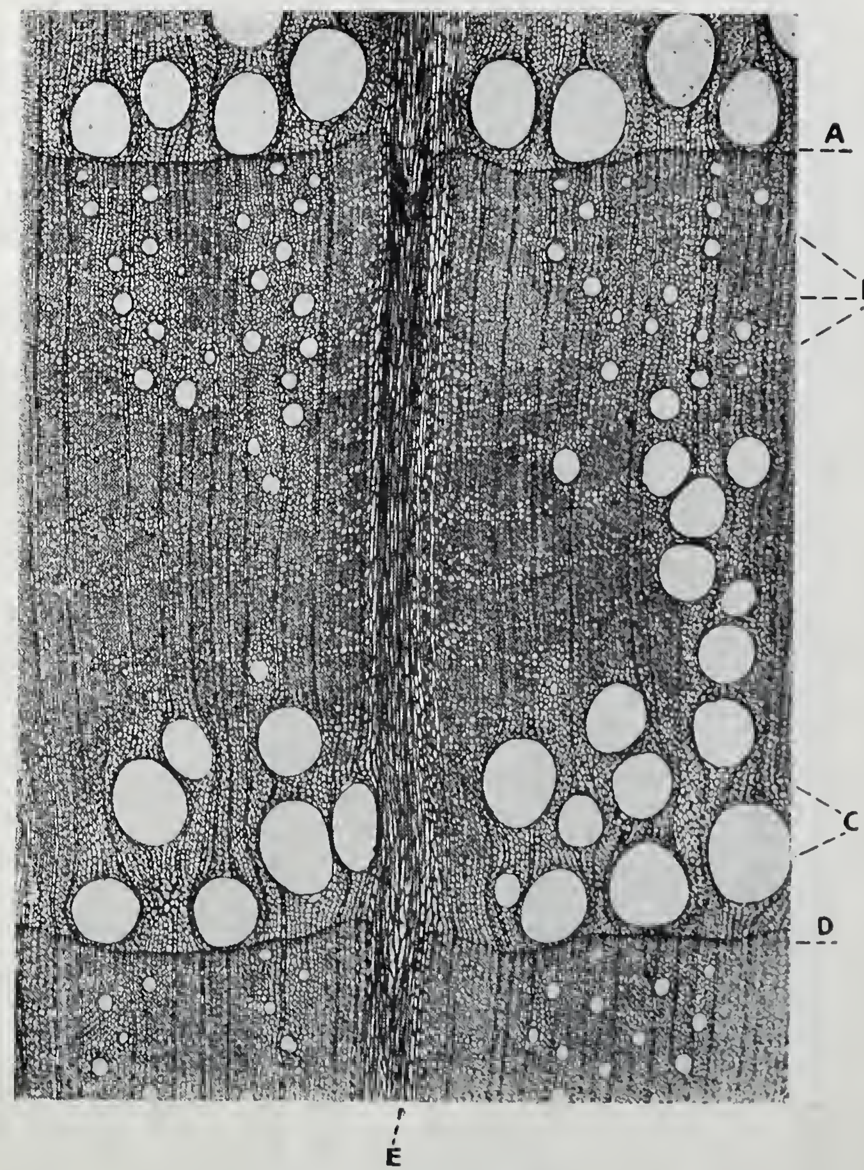


Fig. 4.—Red Oak.

A ring-porous wood. D to A—One year's growth; B—Small pores in summerwood; C—Large pores in springwood; E—Large Medullary rays.

COMPARISON OF DIFFUSE AND RING-POROUS WOODS

In other woods, pores of small and approximately equal size are scattered throughout, with little if any discernible grouping. Such woods are called "diffuse-porous" woods. Common ring-porous woods are ash, oak, elm, and hickory. Among the diffuse-porous woods are birch, beech, basswood, maple, and walnut.

Pith Rays.—In addition to the cells whose length is parallel to the trunk of the tree, wood also contains other layers of cells of a different character whose length is at right angles to the trunk of the tree. These cells occur in thin sheets radiating from the bark toward the pith, and form what are called the "pith rays" or "medullary rays" of wood. They are best seen on a quartered section, and are what gives the beautiful, flaky appearance to quartered oak and sycamore. The pith rays are less conspicuous in beech, maple, and birch, and are scarcely or not at all visible to the naked eye in the pines and many other woods.

Springwood and Summerwood.—When growth begins in the spring, the new cells are large and thin-walled. As the season progresses, smaller and thicker-walled cells are produced, until the last growth of the summer is much denser than the spring growth. It is this contrast between early spring and late summer wood that enables us to distinguish the rings of yearly growth upon a stump or cross-section of a piece of timber. The transition from the large, thin-walled cells of spring to the small, thick-walled cells of summer may be abrupt, as in the yellow pines, or very gradual, as in the white pines and the firs. In the former, the bands of dense wood are very conspicuous; in the latter, they are sometimes scarcely visible to the naked eye. Counting these annual rings on the stump affords an easy and practically accurate means of determining the age of our common trees. Trees which grow in warm climates where there are no fixed cycles of growth and inactivity, do not develop annual rings.

Among the softest, most easily worked woods are white pine, spruce, basswood, and yellow poplar. The first two are non-porous; the last two, diffuse-porous. In all, the transition from springwood to summerwood is very gradual; the cells are thin-walled; and the texture is remarkably uniform. None of these four woods, however, has great strength. Hickory

No. 1. No. 2.

FIG. 5.—Cross-Sections of Loblolly Pine, Showing Variations in Manner of Growth.

No. 1.—Containing large proportion of Springwood; No. 2—Containing large proportion of Summerwood. No. 2 is the stronger.

FIG. 6.—Sapwood and Heartwood in Loblolly Pine.

The darker portion forming the center is the Heartwood, and the surrounding lighter colored ring is the Sapwood.

CROSS-SECTIONS OF LOGS, SHOWING VARIATIONS IN MANNER OF GROWTH

and osage orange, two of our strongest native woods, contain such large pores that, at first glance, one might think they were not strong; but closer examination under the microscope shows a multitude of very small, thick-walled cells which are the source of their remarkable strength.

Sapwood and Heartwood.—A cross-section of the trunk of a living tree will show on the outside a belt of wood of varying width, in which the vital processes of the tree are carried on. Within this belt is a cylinder of older cells, no longer of importance in the growth of the tree, whose function is chiefly that of a support for the great weight of the crown. The outer belt is called the "sapwood"; and the inner cylinder, the "heartwood." The sapwood is light-colored. When tapped, sap flows from it, especially in cold seasons of the year, as in the maples; or resin, as in the pines. As the cells become older, their functions are assumed by newer ones closer to the bark. The living matter of the older cells is gradually replaced by deposits of mineral or other matter, generally of darker color, which produce what is called "heartwood."

It is the dark, richly colored heart of birch, red gum, black walnut, red cedar, redwood, and other trees that yields the beautiful woods for which these species are noted.

Heartwood develops very early in some species, like black locust, osage orange, and catalpa, and very slowly in other species. Black walnut is likely to reach an age of fifty years before much dark heartwood—the valuable portion of the tree—is formed.

The heartwood in some species—basswood and hemlock, for example—is often not clearly distinguishable from the sapwood, and the older cells seem to retain the ability to transmit sap. That the outer portion of the trunk is the main channel of vital activity, however, is proved by the continued growth of trees for many years after they become hollow at the base through decay.

Heartwood is generally heavier than sapwood, and fully as strong if equally free from defects. Moreover, it is usually much more resistant to decay. On the other hand, since its cells are more open, sapwood usually absorbs wood preservatives better than heartwood.

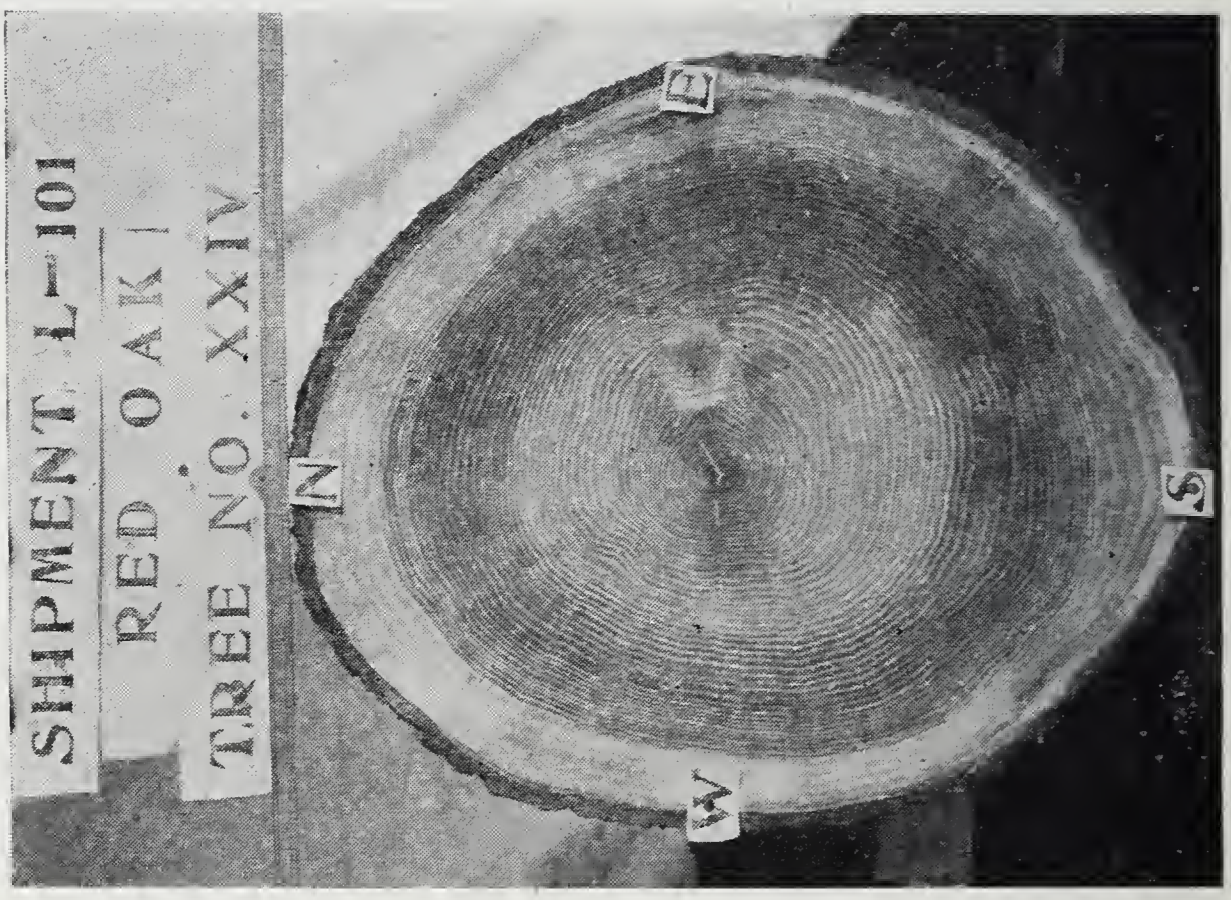


Fig. 7.—Red Oak Log.

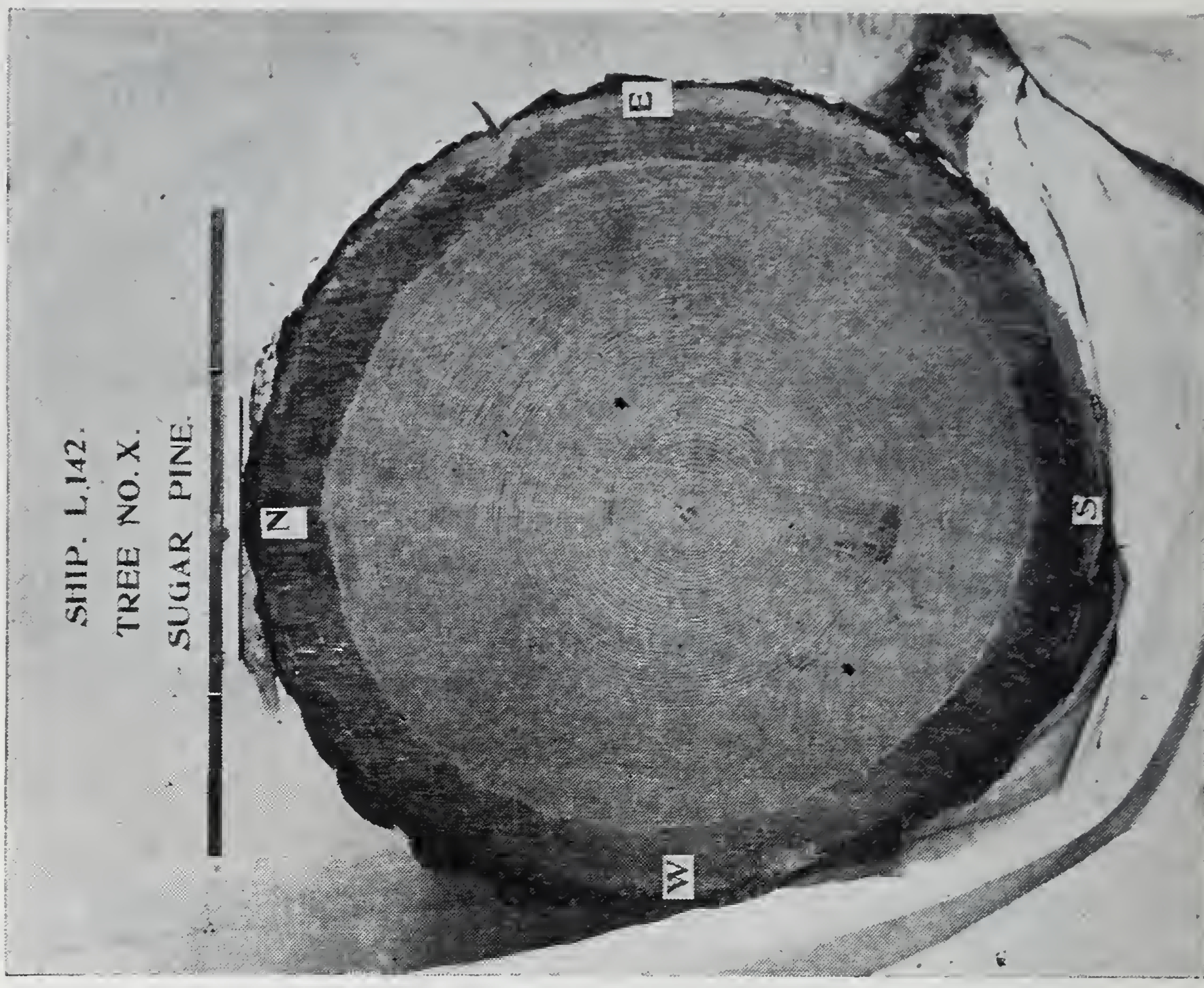


Fig. 8.—Sugar Pine Log.

CROSS-SECTIONS OF LOGS, SHOWING ANNUAL RINGS, HEARTWOOD AND SAPWOOD

The Figure of Wood.—The varying combinations of cells of different kinds, of springwood and summerwood, of heartwood and sapwood, of slow and rapid growth, of knots, burls, dormant buds, and spiral or "curly" grain, produce the many beautiful and characteristic figures which give wood a unique position as a decorative material. These natural variations are still more accentuated by methods of sawing and working, so that the artificer of wood can produce an endless variety of effects without monotony. Figure also is due to irregular infiltrations of coloring matter as in red gum, circassian walnut, and cocobola.

Weight and Strength.—Heavy, thick-walled cells are stronger than light, thin-walled cells; and summerwood stronger than springwood. Hence other factors being equal, the strength of wood is roughly proportional to the dry weight. Given two pieces of wood of the same kind and equally free from defects, the one which is the heavier and contains the larger proportion of summerwood is the stronger. This affords a ready and fairly accurate means of selecting certain kinds of timber. Comparisons of the weight and strength of a number of woods are given on page 18.

What the Microscope Shows.—Cross-sections of four common woods, magnified to the same degree, are shown in Plates 1 to 4. Since the magnification is the same throughout, the character and size of the pores and fibers in these woods are readily compared. Longleaf pine and balsam fir are nonporous woods; oak, ring-porous; and yellow birch, diffuse-porous. In longleaf pine the transition from spring to summerwood is abrupt, resulting in alternating light and dark bands. In the other woods, the transition is very gradual, and often not conspicuous to the naked eye. Comparing size and thickness of fiber walls, it is seen that, for the entire season's growth, the fibers of balsam average the largest and thinnest-walled; those of longleaf pine rank next; those of birch next; and that the oak cells are the smallest and thickest-walled. The larger openings in the longleaf pine are not pores; they are ducts in which the resin collects.

CHAPTER II

PHYSICAL PROPERTIES OF WOOD

The physical properties of wood which determine its usefulness vary with the species, the rate and place of growth, the seasoning condition, and even with individual trees. Two trees are no more exactly alike in either botanical or physical characteristics than are two human beings; hence tabulations purporting to compare the weight, strength, stiffness, or other properties of various woods can be accepted as true only within rather wide limits, and this caution especially applies to the tables in this chapter.

Similar variability, however, is found in other construction materials; and the factors of safety allowed for their use are as great as, or greater than, those for wood.

The commercial terms, "hardwood" and "softwood" do not correspond to the physical characteristics of hardness or softness, and are of little real value in this respect. As ordinarily used, the term "softwood" is given to all trees of the family that the botanists call coniferous or needle-leaved. These are the pines, firs, spruces, hemlocks, cypress, larch, redwood, tamarack, cedars, etc. The term "hardwood" is commonly applied to the species which botanists call broad-leaved, represented by the oaks, maples, hickories, elms, ashes, basswood, beech, birches, walnut, etc. The slightest experience with wood shows that these terms give little indication of the physical properties of the species to which they refer. There are hardwoods softer than the so-called softwoods, and softwoods harder than the so-called hardwoods, although as a group the softwoods average much softer than the hardwoods. Basswood, poplar, aspen, and cottonwood, which are all classified as hardwoods, are in reality among the softest of woods. Longleaf pine, on the other hand, is about as hard as the average hardwood, although it is classified as a

softwood. Comparisons of this sort may be readily made from the tables given in this chapter.

Useful Properties of Wood.—The properties of wood most important from the standpoint of the ordinary user are: weight, strength, stiffness, toughness, hardness, and shrinkage. For some purposes, light weight and stiffness are essential where neither great strength nor toughness is required. For other purposes, strength is by far the most important consideration; and for still other uses, hardness is the determining quality. In some places, it makes little difference how much a piece of wood shrinks; in other places, even a little shrinkage will impair the usefulness of the article. Toughness is essential for many purposes, but not at all necessary for other uses. In some instances ease of working is the determining factor, while in still other instances adaptability to certain finishes is of major importance. There is, thus, a very wide range in the requirements of wood users, which is met by a great diversity of species and physical properties.

The statements in this chapter regarding the physical properties of wood are based upon a series of tests by the United States Forest Service to obtain data for the comparison of the more important species. All the figures are derived from tests of small, clear pieces of wood in green condition. Tests of this character afford the best bâsis for the comparison of various woods; but the figures obtained in this manner do not correspond with the results of tests upon larger-sized material or upon material in the various stages of seasoning ranging from air-dried to kiln-dried. Neither is it safe to assume that the rank of the several species as to weight, strength, stiffness, toughness, and hardness is exactly as indicated by the tables, since many factors such as growth, situation, length of fiber, etc., influence the properties of a given piece of wood. In a broad sense, however, the figures do have a real comparative value, and they are of especial interest since it is the first time that they have been presented in this fashion.

Weight.—The weight of wood is usually expressed by a comparison of the weight of a given volume of wood with that of an equal volume of water, or by what is known as specific gravity. If the specific gravity of a certain kind of wood is

stated as .30, it means that a given volume of this wood weighs .30 times as much as an equal volume of water. Since a cubic foot of water weighs 62.5 pounds, a cubic foot of wood of specific gravity .30 weighs $.30 \times 62.5 = 18.75$ pounds. A piece of wood whose specific gravity is .50 weighs $.50 \times 62.5 = 31.25$ pounds per cubic foot. Similarly, the weight per cubic foot of any kind of wood may be quickly ascertained when the specific gravity is known.

Table 1 gives the specific gravity of a number of hardwoods and softwoods when oven-dry, arranged in order from the lightest to the heaviest in each class. By oven-dry is meant the condition produced by drying wood at a temperature of 212° F. (the boiling point of water) until it ceases to lose moisture.

The average specific gravity of the softwoods listed is .41; and that of the hardwoods, .55; hence the hardwoods average 33 per cent heavier than the softwoods. Several of the softwoods are lighter than any of the hardwoods; but the heaviest of the softwoods, as larch, shortleaf pine, tamarack, and longleaf pine, are heavier than many hardwoods. On the other hand, Table 1 contains 40 hardwoods which are at least twice,

TABLE 1

SPECIFIC GRAVITY OF VARIOUS WOODS

(Based on volume when green and weight when oven dried. Actual weight per cubic foot of these woods equals specific gravity × 62.5 × 1 + moisture percentage.)

SOFTWOODS

Cedar, northern white	.29	Fir, silver	.37
Cedar, western red	.31	Pine, Jeffrey	.37
Fir, alpine	.31	Pine, limber	.37
Spruce, Engelmann	.31	Hemlock, eastern	.38
Fir, balsam	.34	Hemlock, western	.38
Spruce, Sitka	.34	Pine, lodgepole	.38
Cedar, incense	.35	Pine, western yellow	.38
Fir, noble	.35	Spruce, red	.38
Fir, white	.35	Pine, jack	.39
Pine, sugar	.36	Pine, western white	.39
Pine, white	.36	Cypress, yellow	.40
Spruce, white	.36	Douglas fir (Mont.–Wyo.)	.40
Fir, lowland	.37	Cedar, Port Orford	.41
Fir, red	.37	Cypress, bald	.41

TABLE 1—*Continued*

SOFTWOODS—*Continued*

Redwood	.41	Tamarack	.49
Hemlock, mountain	.42	Pine, loblolly	.50
Pine, Norway	.44	Pine, pond	.50
Douglas fir (Wash.-Oreg.)	.45	Pine, shortleaf	.50
Pine, sand	.45	Pinion	.50
Pine, pitch	.47	Pine, longleaf	.55
Juniper, alligator	.48	Pine, slash	.58
Larch, western	.48	Yew, western	.60
Pine, table mountain	.49		

Average specific gravity of softwoods listed, .41

HARDWOODS

Cottonwood, black	.32	Sugarberry	.47
Buckeye, yellow	.33	Ash, pumpkin	.48
Basswood	.33	Elm, slippery	.48
Willow, black	.34	Hackberry	.48
Aspen, largetooth	.35	Maple, red	.48
Aspen	.36	Ash, Oregon	.50
Butternut	.36	Buckthorn, Cascara	.50
Cherry, wild red	.36	Holly, American	.50
Alder, red	.37	Rhododendron, great	.50
Cottonwood	.37	Sourwood	.50
Poplar, yellow	.37	Ash, Biltmore	.51
Willow, western black	.39	Laurel, California	.51
Chestnut	.40	Oak, California black	.51
Umbrella, Fraser	.40	Poisonwood	.51
Sassafras	.42	Walnut, black	.51
Silver-bell tree	.42	Ash, green	.52
Chinquapin, western	.42	Ash, white	.52
Cucumber tree	.44	Oak, Spanish (highland)	.52
Elm, white	.44	Ash, blue	.53
Gum, red	.44	Walnut, Mexican	.53
Maple, broadleaf	.44	Beech	.54
Maple, silver	.44	Birch, yellow	.54
Sumac, staghorn	.45	Hickory, nutmeg	.56
Ash, black	.46	Maple, sugar	.56
Elder, pale	.46	Oak, laurel	.56
Magnolia (evergreen)	.46	Oak, red	.56
Gum, black	.46	Oak, tanbark	.56
Gum, cotton	.46	Oak, water	.56
Sycamore	.46	Oak, willow	.56
Birch, paper	.47	Oak, yellow	.56
Cherry, black	.47	Witch hazel	.56

TABLE 1—*Continued*

HARDWOODS—*Continued*

Madrona	.57	Hornbeam	.63
Oak, chestnut	.57	Dogwood, flowering	.64
Ash, white (second growth)	.58	Hickory, mockernut	.64
Dogwood, western	.58	Hickory, shagbark	.64
Elm, cork	.58	Oak, Pacific post	.64
Oak, bur	.58	Oak, swamp white	.64
Birch, sweet	.59	Persimmon	.64
Hickory, butternut	.60	Hickory, pignut	.66
Hickory, pecan	.60	Locust	.66
Locust, honey	.60	Serviceberry	.66
Oak, cow	.60	Buttonwood, Florida	.69
Oak, post	.60	Oak, canyon live	.70
Oak, white	.60	Inkwood	.73
Applewood	.61	Osage orange	.76
Hickory, water	.61	Plum, pigeon	.77
Oak, Spanish (lowland)	.61	Oak, live	.81
Gum, blue	.62	Blackwood	.83
Haw, pear	.62	Garber stopper	.83
Hickory, big shellbark	.62	Mangrove	.89
Laurel, mountain	.62	Mastic	.89
Oak, gambel	.62	Ironwood, black	1.05

Average specific gravity of hardwoods listed, .55

or more than twice, as heavy as the lightest of the softwoods. Any of these woods, of course, is much heavier when green. For example, the weight of thoroughly dried northern white cedar is 18 pounds per cubic foot, compared with 29 pounds when green; and that of osage orange, 48 pounds per cubic foot, compared with 76 pounds when green.

STRENGTH OF WOODS

It is most important that the users of timber have some idea of the resistance which the common woods offer to cross-breakage, to crushing, and to what is called shearing. The cross-breaking strength of a piece of timber is the load or force which is required to break it when it is supported at the ends and loaded between these points. The crushing strength is the resistance which a stick offers to crushing when loaded as in the case of a railroad tie. The shearing

strength is the resistance offered to a force which tends to make the fibers shear or slide past one another.

Breaking or Bending Strength.—The cross-breaking strength of timber is tested in the laboratory by placing a stick on supports at each end, and loading it at a uniform rate until it breaks. Accurate notation is made of the size of the stick; length of span; the amount of deflection, or the extent to which the stick bends, under various loads; and the weight which finally breaks it. From this information, several factors are determined—one, which best represents the resistance to cross-breakage, being called the modulus of rupture and expressed in pounds per square inch.

The cross-breaking strength of a piece of wood varies inversely with the length of the stick, and directly with the square of the depth; thus, if a weight of 400 pounds breaks a stick 4 feet long, a weight of 200 pounds will break a stick 8 feet long, all other factors being the same. On the other hand, if a weight of 400 pounds breaks a stick 2 inches thick, it will require a weight of $400 \times 2^2 = 1,600$ pounds to break a stick of the same material 4 inches thick.

The modulus of rupture for green sticks of clear wood is indicated in Table 2, which gives the average results of tests upon pieces 2 inches square, with a span of 28 inches. It will be noted that the strength of these woods varies much the same as the weights given in Table 1 (page 12). A very general rule is that light wood is weak and heavy wood strong, or that strength is proportional to weight. There are individual exceptions to this rule, but it holds true for most woods.

TABLE 2

Modulus of Rupture of Various Woods

(Test pieces 2 in. square, 28 in. span, of green, clear wood)

Softwoods

Cedar, Northern white	4,200	Cypress, yellow	6,200
Spruce, Engelmann	4,200	Fir, grand	6,200
Fir, alpine	4,400	Fir, amabilis	6,300
Fir, balsam	4,900	Douglas fir (Mont.–Wyo.)	6,400
Pine, Jeffrey	5,000	Pine, Norway	6,400
Cedar, Western red	5,200	Hemlock, Eastern	6,700
Pine, Western yellow	5,200	Pine, pitch	6,700
Pine, sugar	5,300	Cedar, Port Orford	6,800
Pine, white	5,300	Cypress	6,800
Pine, jack	5,400	Tamarack	7,200
Spruce, white	5,400	Pine, pond	7,400
Pine, lodgepole	5,500	Larch, Western	7,500
Spruce, Sitka	5,500	Pine, loblolly	7,500
Fir, noble	5,700	Pine, table-mountain	7,500
Pine, Western white	5,700	Douglas fir (Oreg.–Wash.)	7,800
Spruce, red	5,700	Pine, shortleaf	8,000
Fir, white	6,000	Pine, longleaf	8,700
Hemlock (Mont.)	6,000	Pine, Cuban	8,800
Hemlock (Wash.)	6,100	Yew, Western	10,100
Cedar, incense	6,200		

Average modulus of rupture of softwoods listed, 6,305

Hardwoods

Willow, black	3,800	Sassafras	6,000
Buckeye, yellow	4,800	Umbrella, Fraser	6,100
Cottonwood, black	4,800	Oak, California black	6,200
Basswood	5,000	Buckthorn, cascara	6,300
Cherry, wild red	5,000	Alder, red	6,500
Aspen	5,300	Hackberry	6,500
Cottonwood	5,300	Holly, American	6,500
Butternut	5,400	Silverbell-tree	6,500
Chestnut	5,600	Sycamore	6,500
Willow, Western black	5,600	Elder, pale	6,600
Poplar, yellow	5,600	Laurel, California	6,600
Aspen, largetooth	5,800	Sugarberry	6,600
Birch, paper	5,800	Gum, red	6,800
Maple, silver	5,800	Elm, white	6,900
Sumac, staghorn	5,800	Oak, Spanish (highland)	6,900
Ash, black	6,000	Rhododendron, great	6,900

TABLE 2—*Continued*

HARDWOODS—*Continued*

Chinquapin, Western	7,000	Birch, sweet	8,600
Gum, black	7,000	Birch, yellow	8,600
Oak, bur	7,200	Dogwood, flowering	8,800
Gum, cotton	7,300	Oak, water	8,900
Maple, Oregon	7,400	Ash, white	9,100
Oak, willow	7,400	Hickory, nutmeg	9,100
Cucumber tree	7,400	Maple, sugar	9,100
Ash, Oregon	7,600	Ash, Biltmore	9,300
Ash, pumpkin	7,600	Ash, green	9,500
Haw, pear	7,600	Elm, cork	9,500
Madrona	7,600	Walnut, black	9,500
Oak, Pacific post	7,700	Ash, blue	9,600
Oak, red	7,700	Serviceberry	9,600
Sourwood	7,700	Hickory, pecan	9,800
Maple, red	7,800	Persimmon	10,000
Oak, laurel	7,900	Locust, honey	10,200
Elm, slippery	8,000	Hickory, butternut	10,300
Cherry, black	8,000	Hickory, big shellbark	10,500
Oak, chestnut	8,000	Oak, canyon live	10,600
Oak, post	8,100	Hickory, water	10,700
Oak, yellow	8,200	Ash, white	10,800
Dogwood, Western	8,200	Oak, Spanish (lowland)	10,800
Beech	8,200	Hickory, shagbark	11,000
Oak, white	8,300	Hickory, mockernut	11,100
Witch hazel	8,300	Gum, blue	11,200
Laurel, mountain	8,400	Hickory, pignut	11,700
Oak, cow	8,500	Locust, black	13,800
Hornbeam	8,500		

Average modulus of rupture of hardwoods listed, 7,817

The softwoods are not generally so strong as the hardwoods; but some hardwoods are weaker than some softwoods; and some softwoods, notably longleaf pine, are stronger than many hardwoods. The ratio of bending strength to weight is about the same for hardwoods and softwoods. Dividing the modulus of rupture by the specific gravity (ciphers being dropped) gives the results shown in Table 3.

TABLE 3

Ratio of Bending Strength to Weight of Various Woods

Softwoods

Fir, noble	106	Pine, Cuban	152
Pine Jeffrey	135	Pine, table-mountain	153
Spruce, Engelmann	136	Cypress, yellow	155
Pine, Western yellow	137	Larch, western	156
Pine, jack	139	Pine, longleaf	159
Fir, alpine	142	Douglas fir (Mont.–Wyo.)	160
Hemlock, black	143	Pine, shortleaf	160
Pine, pitch	143	Hemlock, Western	161
Fir, balsam	144	Spruce, Sitka	162
Cedar, white	145	Fir, grand	165
Pine, lodgepole	145	Cedar, Port Orford	166
Pine, Norway	145	Cypress, bald	166
Pine, Western white	146	Cedar, Western red	168
Pine, sugar	147	Yew, Western	168
Pine, white	147	Fir, amabilis	170
Tamarack	147	Fir, white	171
Pine, pond	148	Douglas fir (Wash.–Oreg.)	173
Pine, loblolly	150	Hemlock, Eastern	176
Spruce, red	150	Cedar, incense	177
Spruce, white	150		

Average ratio bending strength to weight of softwoods listed, 153

Hardwoods

Willow, black	112	Oak, post	135
Oak, Pacific post	120	Dogwood, flowering	138
Oak, California black	122	Oak, red	138
Birch, paper	123	Oak, white	138
Haw, pear	123	Rhododendron, great	138
Oak, bur	124	Cherry, wild red	139
Buckthorn, cascara	126	Chestnut	140
Sumac, staghorn	129	Oak, chestnut	140
Ash, black	130	Sugarberry	140
Holly, American	130	Dogwood, Western	141
Maple, silver	132	Oak, laurel	141
Laurel, California	132	Sycamore	141
Oak, yellow	132	Oak, cow	142
Oak, Spanish (highland)	133	Cottonwood	143
Madrona	133	Sassafras	143
Hackberry	135	Elder, pale	144
Hornbeam	135	Willow, Western black	144
Laurel, mountain	135	Buckeye, yellow	145

TABLE 3—*Continued*

HARDWOODS—*Continued*

Serviceberry	145	Maple, red	163
Birch, sweet	146	Maple, sugar	163
Oak, yellow	146	Elm, cork	164
Aspen	147	Aspen, largetooth	166
Magnolia	148	Chinquapin, Western	167
Witch hazel	148	Elm, slippery	167
Butternut	150	Cucumber-tree	168
Cottonwood, black	150	Maple, Oregon	168
Oak, canyon live	151	Hickory, big shellbark	169
Ash, Oregon	152	Cherry, black	170
Basswood	152	Locust, honey	170
Beech	152	Hickory, bitternut	172
Gum, black	152	Hickory, mockernut	173
Umbrella, Fraser	153	Hickory, shagbark	173
Sourwood	154	Ash, white (forest grown)	175
Gum, red	155	Hickory, water	175
Silverbell-tree	155	Alder, red	176
Persimmon	156	Hickory, pignut	177
Poplar, yellow	156	Oak, Spanish (lowland)	177
Elm, white	157	Ash, blue	181
Ash, pumpkin	158	Gum, blue	181
Birch, yellow	159	Ash, Biltmore	182
Gum, cotton	159	Ash, green	183
Oak, water	159	Ash, white (second growth)	186
Hickory, nutmeg	163	Walnut, black	186
Hickory, pecan	163	Locust, black	209

Average ratio bending strength to weight of hardwoods listed, 152

It appears that, among the hardwoods, black locust is the strongest in proportion to its weight, and willow the weakest. Incense cedar is the strongest softwood in proportion to its weight. In fact, incense cedar appears to be the strongest in proportion to weight of any wood, with the exception of black locust, yet tested at the Forest Products Laboratory.

As with the other tables in this chapter, these results are to be taken only in a broad sense.

Crushing Strength.—The resistance which a short post or a column offers to a weight placed on top is called its end-crushing strength, or strength in compression parallel to the grain. The crushing strength is expressed in terms of the weight required to crush a stick 1 inch square in cross-section, or in pounds per square inch.

The crushing strength of green wood of the principal species is approximately as indicated in Table 4.

TABLE 4

CRUSHING STRENGTH OF VARIOUS WOODS

(Based on tests of small clear sticks of green wood. Pounds per square inch; pressure applied parallel to grain)

SOFTWOODS

Spruce, Engelmann	1,980	Douglas fir (Mont.–Wyo.)	3,000
Cedar, white	1,990	Fir, grand	3,010
Fir, alpine	2,060	Pine, pitch	3,040
Pine, Jeffrey	2,370	Pine, Western white	3,070
Spruce, white	2,380	Pine, Norway	3,080
Fir, balsam	2,400	Cedar, incense	3,150
Pine, Western yellow	2,460	Hemlock, Eastern	3,270
Pine, jack	2,580	Cedar, Port Orford	3,280
Pine, sugar	2,600	Tamarack	3,480
Spruce, Sitka	2,600	Cypress, bald	3,490
Pine, lodgepole	2,610	Pine, table-mountain	3,540
Fir, noble	2,700	Pine, loblolly	3,580
Pine, white	2,720	Pine, pond	3,660
Spruce, red	2,740	Larch, Western	3,800
Fir, white	2,800	Pine, shortleaf	3,810
Cedar, Western red	2,840	Douglas fir (Wash.–Oreg.)	3,940
Cypress, yellow	2,880	Pine, longleaf	4,390
Hemlock, black	2,890	Pine, Cuban	4,470
Hemlock, Western	2,890	Yew, Western	4,600
Fir, amabilis	2,930		

Average crushing strength of softwoods listed, 3,053

HARDWOODS

Willow, black	1,510	Umbrella, Fraser	2,610
Buckeye, yellow	2,050	Holly, American	2,640
Aspen	2,160	Hackberry	2,650
Cottonwood, black	2,160	Sumac, staghorn	2,680
Cherry, wild red	2,170	Magnolia	2,700
Basswood	2,210	Aspen, largetooth	2,720
Birch, paper	2,210	Sassafras	2,730
Cottonwood	2,280	Sugarberry	2,800
Ash, black	2,290	Oak, California black	2,800
Willow, Western black	2,340	Silverbell-tree	2,830
Butternut	2,420	Gum, red	2,840
Chestnut	2,470	Elm, white	2,880
Maple, silver	2,490	Sycamore	2,920
Poplar, yellow	2,550	Alder	2,960

TABLE 4—*Continued*

HARDWOODS—*Continued*

Oak, willow	3,000	Oak, white	3,560
Chinquapin, Western	3,020	Hornbeam	3,570
Laurel, California	3,020	Oak, Pacific post	3,570
Oak, Spanish (highland)	3,030	Dogwood	3,640
Elder, pale	3,040	Dogwood, Western	3,640
Gum, black	3,040	Oak, water	3,740
Haw, pear	3,110	Elm, cork	3,780
Cucumber tree	3,140	Ash, white	3,800
Oak, laurel	3,170	Maple, sugar	3,860
Oak, red	3,200	Ash, Biltmore	3,980
Maple, Oregon	3,240	Hickory, nutmeg	3,980
Sourwood	3,250	Hickory, pecan	3,990
Buckthorn, cascara	3,270	Serviceberry	4,080
Beech	3,280	Persimmon	4,170
Oak, burr	3,290	Ash, blue	4,180
Elm, slippery	3,320	Ash, green	4,200
Madrona	3,320	Walnut, black	4,300
Maple, red	3,350	Laurel, mountain	4,310
Ash, pumpkin	3,360	Locust, honey	4,420
Gum, cotton	3,370	Hickory, mockernut	4,480
Witch hazel	3,400	Hickory, bitternut	4,570
Birch, yellow	3,460	Hickory, shagbark	4,580
Oak, yellow	3,460	Ash, white	4,610
Rhododendron, great	3,470	Oak, Spanish (lowland)	4,620
Oak, post	3,480	Hickory, water	4,660
Ash, Oregon	3,510	Oak, canyon live	4,690
Oak, chestnut	3,520	Hickory, pignut	4,810
Cherry, black	3,540	Gum, blue	5,250
Oak, cow	3,540	Locust, black	6,800
Birch, sweet	3,560		

Average crushing strength of hardwoods listed, 3,293

Tensile Strength.—Tensile strength is the opposite of crushing strength, or the force required to pull a substance apart. The tensile strength of wood parallel to the grain is from two to four times as great as the corresponding crushing strength, and considerably greater for hardwoods than for softwoods. When placed under compression, the fibers of wood tend to buckle or bend, and thus give way; but they offer great resistance to a force which tends to pull them apart.

Although the tensile strength of wood is many times re-

ferred to, in popular statements, as being a most important property, it is really not so necessary to determine, for most uses, as the resistance to bending and crushing. For all ordinary purposes, the tensile strength of wood is greater than stress of this sort to which it will be subjected, and hence no detailed discussion of the topic is necessary.

Shearing Strength.—The resistance which wood offers to a force which tends to make the fibers slip one on another, is called shearing strength, and for many uses it is important that the shearing strength parallel to the grain be determined. Resistance to shear is a necessary quality in wood paving blocks. The figures upon the comparative shearing strength of the various species of wood, as determined by tests upon small pieces, shown in Table 5, are given in pounds per square inch.

TABLE 5

SHEARING STRENGTH OF VARIOUS WOODS

(Based on tests of small, clear sticks of green wood. Pounds per square inch)

SOFTWOODS

Spruce, Engelmann	590	Hemlock, Western	810
Fir, alpine	610	Cypress, bald	820
Fir, balsam	610	Cypress, yellow	820
Cedar, white	620	Cedar, incense	830
Pine, white	640	Tamarack	860
Fir, amabilis	670	Cedar, Port Orford	880
Spruce, white	670	Douglas fir (Mont.–Wyo.)	880
Pine, Western yellow	680	Hemlock, black	880
Pine, Jeffrey	690	Hemlock, Eastern	880
Pine, lodgepole	690	Pine, shortleaf	890
Fir, noble	700	Pine, loblolly	900
Pine, sugar	710	Douglas fir (Wash.–Oreg.)	910
Pine, Western white	710	Larch, Western	920
Cedar, Western red	720	Pine, pond	940
Fir, white	730	Pine, pitch	950
Fir, grand	760	Pine, table-mountain	960
Pine, jack	760	Pine, Cuban	1,030
Spruce, red	770	Pine, longleaf	1,070
Pine, Norway	780	Yew, Western	1,620
Spruce, Sitka	780		

Average shearing strength of softwoods listed, 814

TABLE 5—*Continued*

HARDWOODS

Cottonwood, black	600	Oak, yellow	1,180
Basswood	610	Ash, Oregon	1,190
Aspen	620	Gum, cotton	1,190
Willow, black	620	Hickory, big shellbark	1,190
Buckeye, yellow	660	Ash, pumpkin	1,210
Cherry, wild red	680	Beech	1,210
Cottonwood	680	Oak, chestnut	1,210
Butternut	760	Birch, sweet	1,220
Alder, red	770	Walnut, black	1,220
Birch, paper	790	Ash, Biltmore	1,230
Poplar, yellow	790	Hickory, bitternut	1,240
Chestnut	800	Oak, water	1,240
Aspen, largetooth	810	Rhododendron, great	1,240
Umbrella, Fraser	830	Oak, white	1,250
Ash, black	870	Ash, green	1,260
Willow, Western black	870	Ash, white	1,260
Elm, white	920	Oak, cow	1,260
Oak, Spanish (highland)	930	Serviceberry	1,260
Silverbell-tree	930	Elm, cork	1,270
Sassafras	950	Laurel, California	1,270
Cucumber tree	990	Hickory, mockernut	1,280
Sycamore	1,000	Oak, post	1,280
Chinquapin, Western	1,010	Dogwood, Western	1,300
Hickory, nutmeg	1,030	Hickory, shagbark	1,320
Magnolia	1,040	Oak, Spanish (lowland)	1,320
Maple, silver	1,050	Oak, bur	1,350
Sugarberry	1,050	Haw, pear	1,360
Gum, red	1,070	Hickory, pignut	1,370
Hackberry	1,070	Hornbeam	1,370
Maple, red	1,080	Maple, sugar	1,380
Elder, pale	1,090	Madrona	1,420
Gum, black	1,100	Hickory, water	1,440
Birch, yellow	1,110	Persimmon	1,470
Elm, slippery	1,110	Hickory, pecan	1,480
Maple, Oregon	1,110	Dogwood	1,520
Oak, red	1,120	Ash, blue	1,540
Witch hazel	1,120	Gum, blue	1,550
Cherry, black	1,130	Ash, white	1,600
Holly, American	1,130	Oak, Pacific post	1,630
Oak, California black	1,140	Locust, honey	1,660
Buckthorn, cascara	1,150	Laurel, mountain	1,670
Sourwood	1,160	Oak, canyon live	1,700
Oak, laurel	1,180	Locust, black	1,760
Oak, willow	1,180		

Average shearing strength of hardwoods listed, 1,165

STIFFNESS

Stiffness is the resistance which a stick offers to a force that tends to change its shape. The stiffness of a stick of wood varies directly with the cube of its thickness, and inversely with the cube of its length. In other words, doubling the length of a stick makes it only one-eighth as stiff as previously; doubling the thickness makes it eight times as stiff as before.

Timber testing engineers express the stiffness of wood by what is called the modulus of elasticity, which is stated in 1,000 pounds per square inch. The modulus of elasticity for the principal woods tested in a green condition is indicated in Table 6.

TABLE 6

Modulus of Elasticity of Various Woods

(Based on tests of small clear sticks of green wood. Modulus given in thousands of pounds per square inch)

Softwoods

Cedar, white	640	Spruce, red	1,180
Spruce, Engelmann	830	Spruce, Sitka	1,180
Cedar, incense	840	Cypress, bald	1,190
Fir, alpine	860	Hemlock, Western	1,190
Pine, jack	920	Tamarack	1,240
Hemlock, black	940	Pine, table-mountain	1,270
Cedar, Western red	950	Fir, noble	1,280
Cypress, yellow	960	Pine, pond	1,280
Fir, balsam	960	Fir, amabilis	1,300
Pine, sugar	970	Fir, grand	1,300
Pine, Jeffrey	980	Pine, Western white	1,330
Spruce, white	980	Larch, Western	1,350
Yew, Western	990	Pine, loblolly	1,380
Pine, Western yellow	1,010	Pine, Norway	1,380
Pine, white	1,070	Pine, shortleaf	1,450
Pine, lodgepole	1,080	Cedar, Port Orford	1,500
Hemlock, Eastern	1,120	Douglas fir (Oreg.–Wash.)	1,580
Pine, pitch	1,120	Pine, Cuban	1,630
Fir, white	1,130	Pine, longleaf	1,630
Douglas fir (Mont.–Wyo.)	1,180		

Average modulus of elasticity of softwoods listed, 1,158

TABLE 6—*Continued*

HARDWOODS

Willow, black	560	Alder, red	1,170
Buckthorn, cascara	630	Aspen, largetooth	1,180
Laurel, California	720	Dogwood, flowering	1,180
Oak, California black	740	Oak, yellow	1,180
Oak, Pacific Post	790	Elm, cork	1,190
Sumac, staghorn	810	Umbrella, Fraser	1,190
Sugarberry	810	Poplar, yellow	1,210
Aspen	840	Elm, slippery	1,230
Rhododendron, great	870	Ash, blue	1,240
Madrona	880	Beech	1,240
Oak, bur	880	Oak, white	1,250
Elder, pale	900	Hickory, nutmeg	1,290
Holly, American	900	Locust, honey	1,290
Sassafras	910	Oak, red	1,290
Laurel, mountain	920	Oak, willow	1,290
Chestnut	930	Cherry, black	1,310
Maple, silver	940	Sourwood	1,320
Hackberry	950	Ash, Biltmore	1,340
Haw, pear	960	Hickory, big shellbark	1,340
Butternut	970	Oak, canyon live	1,340
Buckeye, yellow	980	Ash, white	1,350
Birch, paper	1,010	Oak, cow	1,350
Cottonwood	1,010	Hickory, pecan	1,370
Ash, black	1,020	Oak, chestnut	1,370
Chinquapin	1,020	Persimmon	1,370
Willow, Western black	1,020	Oak, laurel	1,390
Basswood	1,030	Ash, green	1,400
Elm, white	1,030	Hickory, bitternut	1,400
Gum, black	1,030	Maple, red	1,420
Ash, pumpkin	1,040	Walnut, black	1,420
Cherry, wild red	1,040	Maple, sugar	1,480
Gum, cotton	1,050	Birch, sweet	1,490
Sycamore	1,060	Birch, yellow	1,540
Cottonwood, black	1,070	Oak, water	1,550
Dogwood, Western	1,090	Cucumber-tree	1,560
Oak, post	1,090	Hickory, water	1,560
Maple, Oregon	1,100	Hickory, mockernut	1,570
Magnolia	1,110	Hickory, shagbark	1,570
Witch hazel	1,110	Ash, white	1,640
Ash, Oregon	1,130	Serviceberry	1,640
Oak, Spanish (highland)	1,140	Hickory, pignut	1,650
Gum, red	1,150	Oak, Spanish (lowland)	1,790
Hornbeam	1,150	Locust, black	1,850
Silverbell-tree	1,160	Gum, blue	2,010

Average modulus of elasticity of hardwoods listed, 1,186

The softwoods are nearly as stiff as the hardwoods, and, in comparison with their weights, much stiffer than the hardwoods. For example, Western red cedar, with a specific gravity of only .31 has a modulus of elasticity of 950,000 pounds per square inch; while mountain laurel, which is twice as heavy, is not quite so stiff as western red cedar. A study of the tables affords many interesting comparisons of this sort.

TOUGHNESS

Toughness is the ability to bend without breaking. It is one of the most useful properties of wood, and is especially desirable in handles, spokes, and various other articles.

The toughness of wood is not exactly determined by any single mechanical test. Perhaps it is best indicated by two tests which the engineers designate as the work to maximum load, and resistance to impact. The work to maximum load is expressed in inch-pounds per cubic inch; and the resistance to impact, in the height in inches necessary to drop a 50-pound hammer to cause complete breakage of the stick tested. The results of tests of this character are given in Table 7.

TABLE 7

Toughness Tests of Various Woods

(Based on tests of small clear sticks of green wood. Work to maximum load. Inch-pounds per cubic inch)

Softwoods

Fir, alpine	4.4	Pine, jack	5.9
Fir, balsam	4.7	Pine, white	5.9
Pine, Jeffrey	4.7	Fir, amabilis	6.0
Spruce, Engelmann	4.9	Hemlock, Western	6.0
Cedar, Western red	5.0	Spruce, red	6.1
Pine, sugar	5.0	Fir, noble	6.2
Pine, Western white	5.1	Cedar, incense	6.4
Pine, Western yellow	5.1	Cypress, bald	6.4
Fir, white	5.2	Spruce, Sitka	6.4
Fir, grand	5.6	Douglas fir (Oreg.–Wash.)	6.7
Pine, lodgepole	5.6	Douglas fir (Mont.–Wyo.)	6.8
Cedar, white	5.7	Hemlock, Eastern	6.8
Spruce, white	5.7	Larch, Western	7.1
Pine, Norway	5.8	Tamarack	7.2

TABLE 7—*Continued*

SOFTWOODS—*Continued*

Pine, pond	7.5	Pine, pitch	8.5
Cedar, Port Orford	7.8	Pine, shortleaf	8.7
Pine, Cuban	7.9	Hemlock, black	9.4
Pine, loblolly	8.0	Cypress, yellow	9.5
Pine, longleaf	8.0	Yew, Western	20.2
Pine, table-mountain	8.1		

Average work to maximum load of softwoods listed, 6.8

HARDWOODS

Cottonwood, black	5.0	Oak, post	11.0
Basswood	5.2	Oak, water	11.1
Buckeye, yellow	5.4	Madrona	11.2
Poplar, yellow	5.6	Oak, laurel	11.2
Aspen, largetooth	6.1	Oak, red	11.5
Cherry, wild red	6.2	Oak, white	11.5
Aspen	6.9	Ash, Biltmore	11.6
Chestnut	7.0	Ash, green	11.8
Sassafras	7.1	Maple, sugar	11.9
Cottonwood	7.3	Sugarberry	12.0
Sycamore	7.5	Rhododendron, great	12.1
Alder, red	8.0	Ash, Oregon	12.2
Gum, black	8.0	Oak, yellow	12.3
Oak, Spanish (highland)	8.0	Ash, black	12.4
Butternut	8.2	Beech	12.5
Gum, cotton	8.3	Laurel, mountain	12.5
Umbrella, Fraser	8.3	Locust, honey	12.6
Maple, Oregon	8.7	Cherry, black	12.8
Elder, pale	8.8	Oak, cow	12.8
Oak, willow	8.8	Persimmon	13.0
Silverbell-tree	8.8	Hackberry	13.3
Ash, pumpkin	9.4	Ash, white	13.4
Gum, red	9.4	Buckthorn, cascara	13.4
Oak, chestnut	9.4	Oak, Pacific post	13.7
Chinquapin, Western	9.5	Gum, blue	13.9
Sourwood	9.8	Oak, canyon live	14.4
Cucumber-tree	10.0	Hackberry	14.5
Maple, red	10.6	Hickory, pecan	14.6
Oak, bur	10.7	Walnut, black	14.6
Holly, American	10.8	Ash, blue	14.7
Sumac, staghorn	10.8	Oak, Spanish (lowland)	14.7
Willow, black	10.8	Birch, paper	15.0
Willow, Western black	10.8	Elm, slippery	15.4
Elm, white	11.0	Locust, black	15.4
Maple, silver	11.0	Magnolia	15.4

TABLE 7—*Continued*

HARDWOODS—*Continued*

Birch, sweet	15.6	Hickory, bitternut	20.0
Silverbell-tree	16.2	Dogwood, flowering	21.0
Ash, white (2nd growth)	16.3	Haw, pear	22.7
Birch, yellow	16.6	Hickory, nutmeg	22.8
Laurel, California	16.8	Hickory, shagbark	23.7
Dogwood, Western	17.0	Hickory, mockernut	26.1
Hickory, water	18.8	Hickory, big shellbark	29.9
Witch hazel	19.5	Hickory, pignut	31.7
Elm, cork	19.8		

Average work to maximum load of hardwoods listed, 12.7

RESISTANCE TO IMPACT

(Height in inches at which drop of a 50-lb. hammer caused breakage of test piece)

SOFTWOODS

Fir, alpine	9	Pine, Western white	23
Spruce, Engelmann	14	Cypress, bald	24
Cedar, white	15	Larch, Western	24
Fir, balsam	16	Cedar, Port Orford	25
Cedar, incense	17	Douglas fir (Wash.–Oreg.)	25
Cedar, Western red	17	Cypress, yellow	27
Pine, sugar	17	Pine, Norway	28
Fir, white	18	Tamarack	28
Pine, white	18	Pine, pitch	29
Spruce, red	18	Pine, table-mountain	29
Pine, Western yellow	19	Spruce, Sitka	29
Douglas fir (Mont.–Wyo.)	20	Pine, jack	30
Fir, noble	20	Pine, loblolly	32
Hemlock, Eastern	20	Pine, pond	33
Hemlock, Western	20	Pine, longleaf	34
Pine, lodgepole	20	Hemlock, black	36
Spruce, white	20	Pine, Cuban	37
Fir, amabilis	21	Yew, Western	38
Pine, Jeffrey	21	Pine, shortleaf	39
Fir, grand	22		

Average resistance to impact of softwoods listed, 24

HARDWOODS

Basswood	17	Buckeye, yellow	18
Poplar, yellow	17	Cottonwood, black	20
Aspen, largetooth	18	Cottonwood	21

TABLE 7—*Continued*

HARDWOODS—*Continued*

Alder, red	22	Birch, yellow	40
Cherry, wild red	22	Gum, blue	40
Magnolia	23	Locust, honey	40
Umbrella, Fraser	23	Oak, yellow	40
Butternut	24	Witch hazel	40
Chestnut	24	Oak, red	41
Rhododendron, great	26	Oak, yellow	41
Sycamore	26	Oak, white	42
Silverbell-tree	27	Ash, blue	43
Aspen	28	Birch, sweet	44
Maple, red	29	Laurel, mountain	44
Oak, Spanish (highland)	29	Maple, sugar	44
Ash, Biltmore	30	Oak, post	44
Cucumber tree	30	Birch, paper	45
Gum, black	30	Oak, cow	45
Gum, cotton	30	Ash, white (second growth)	47
Maple, Oregon	30	Elm, slippery	47
Oak, bur	30	Locust, black	47
Ash, pumpkin	31	Oak, California black	47
Chinquapin, Western	31	Oak, canyon live	47
Ash, black	32	Hackberry	48
Laurel, California	32	Oak, Pacific post	49
Cherry, black	33	Elm, cork	50
Gum, red	33	Oak, water	51
Sugarberry	33	Hickory, nutmeg	53
Willow, Western black	33	Hickory, mockernut	54
Ash, green	34	Madrona	54
Elm, white	34	Oak, Spanish (lowland)	54
Oak, chestnut	35	Dogwood, Western	56
Oak, willow	35	Hickory, shagbark	56
Ash, white (forest grown)	36	Hornbeam	57
Maple, silver	36	Buckthorn, cascara	58
Willow, black	36	Dogwood, flowering	58
Sassafras	37	Serviceberry	63
Walnut, black	37	Hickory, big shellbark	66
Elder, pale	38	Holly, American	73
Sourwood	38	Hickory, pignut	74
Ash, Oregon	39	Hickory, bitternut	88
Oak, laurel	39	Hickory, pecan	89
Oak, water	39	Haw, pear	104
Beech	40		

Average resistance to impact of hardwoods listed, 41

As a class, the hardwoods are nearly twice as tough as the softwoods, although, as in previous tests, there is an over-

lapping of the two groups. Alpine fir is the least tough of the softwoods, and Western yew the toughest, the latter being tougher than a number of hardwoods. Black cottonwood and basswood have the least toughness among the hardwoods; the hickories are the toughest, the range being very wide.

HARDNESS

Hardness is a most important property of wood, since resistance to wear is necessary for a large number of purposes. In the Forest Service tests, hardness is determined by the weight required to force a steel ball .444 of an inch in diameter one-half its diameter into the wood. The tests upon green wood give the results shown in Table 8, the species being arranged from the softest to the hardest as expressed by the pressure in pounds necessary to make the required indentation.

TABLE 8

HARDNESS OF VARIOUS WOODS

(Based on tests of clear, green wood transverse to grain. Pressure in pounds required to indent specimen to depth of one-half diameter of a .444 diameter steel ball)

SOFTWOODS

Fir, alpine	220	Cypress, bald	380
Cedar, white	230	Tamarack	380
Spruce, Engelmann	240	Cedar, incense	390
Fir, noble	250	Douglas fir (Mont.–Wyo.)	400
Cedar, Western red	260	Cypress, yellow	410
Spruce, white	280	Hemlock, Eastern	410
Fir, balsam	290	Hemlock, Western	430
Pine, white	300	Larch, Western	450
Fir, amabilis	310	Pine, loblolly	450
Pine, sugar	320	Hemlock, black	460
Pine, Western yellow	320	Douglas fir (Wash.–Oreg.)	470
Fir, white	330	Cedar, Port Orford	480
Pine, lodgepole	330	Pine, pitch	480
Pine, Western white	330	Pine, table-mountain	490
Pine, Jeffrey	340	Pine, pond	510
Pine, Norway	340	Pine, shortleaf	560
Spruce, red	350	Pine, longleaf	590
Fir, grand	360	Pine, Cuban	630
Pine, jack	370	Yew, Western	1,150
Spruce, Sitka	370		

Average hardness of various softwoods listed, 402

TABLE 8—*Continued*

HARDWOODS—*Continued*

Cottonwood, black	230	Beech	820
Basswood	250	Ash, Biltmore	850
Buckeye, yellow	290	Oak, California black	850
Aspen	320	Oak, Spanish (highland)	860
Cottonwood	340	Rhododendron, great	860
Poplar, yellow	340	Ash, green	870
Willow, black	360	Birch, sweet	890
Aspen, largetooth	370	Oak, chestnut	890
Butternut	390	Ash, white (forest grown)	900
Cherry, wild red	390	Walnut, black,	900
Chestnut	420	Maple, sugar	910
Alder, red	440	Madrona	940
Silverbell-tree	470	Oak, red	950
Birch, paper	490	Dogwood, Western	980
Umbrella, Fraser	500	Oak, willow	980
Willow, Western black	500	Witch hazel	980
Cucumber tree	520	Elm, cork	990
Gum, red	520	Laurel, California	1,000
Sassafras	520	Oak, water	1,010
Ash, black	550	Ash, blue	1,030
Elm, white	550	Oak, white	1,060
Maple, silver	590	Oak, yellow	1,060
Sumac, staghorn	590	Ash, white (second growth)	1,080
Chinquapin, Western	600	Oak, bur	1,110
Maple, red	600	Oak, cow	1,110
Sycamore	610	Oak, post	1,130
Maple, Oregon	620	Hornbeam	1,170
Gum, black	640	Haw, pear	1,200
Cherry, black	660	Oak, Spanish (lowland)	1,240
Elm, slippery	660	Serviceberry	1,240
Hackberry	690	Persimmon	1,280
Gum, cotton	710	Laurel, mountain	1,300
Elder, pale	720	Hickory, pecan	1,310
Sourwood	730	Gum, blue	1,340
Birch, yellow	740	Locust, honey	1,390
Magnolia	740	Oak, Pacific post	1,390
Sugarberry	740	Dogwood, flowering	1,410
Ash, pumpkin	750	Locust, black	1,570
Ash, Oregon	790	Oak, canyon live	1,570
Holly, American	790		

Average hardness of various hardwoods listed, 812

The hardwoods as a class average from two to three times as hard as the softwoods. The hardest softwood, Western yew,

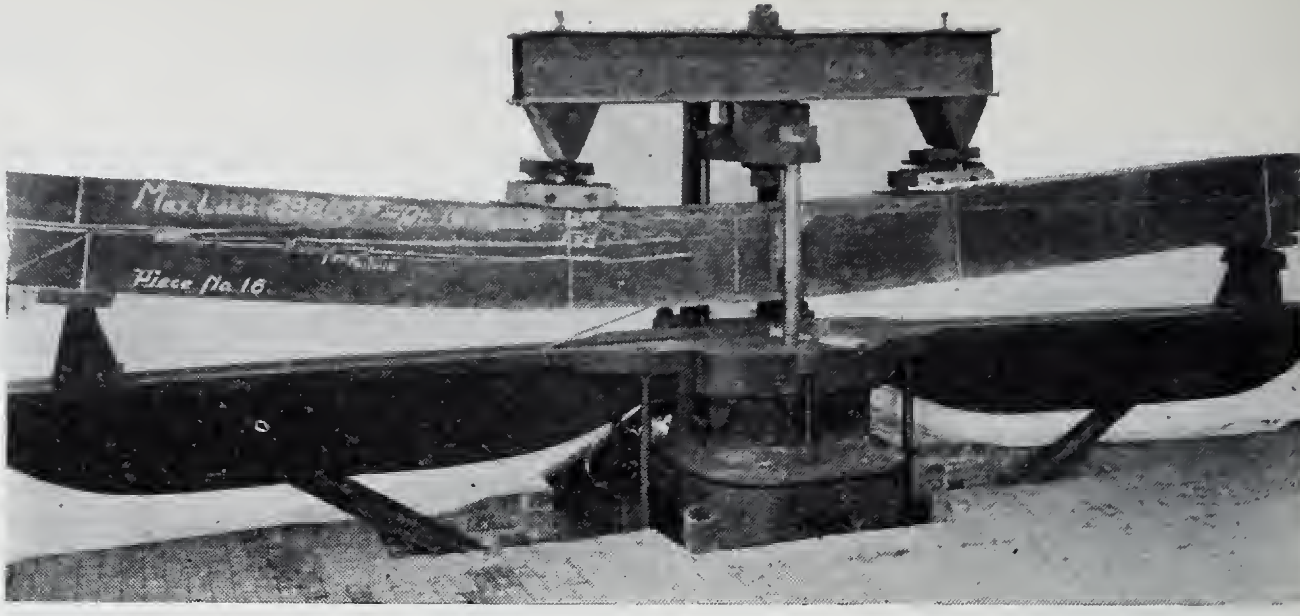


FIG. 9.—Bending Test of a Beam of Air-Dry Shortleaf Pine.

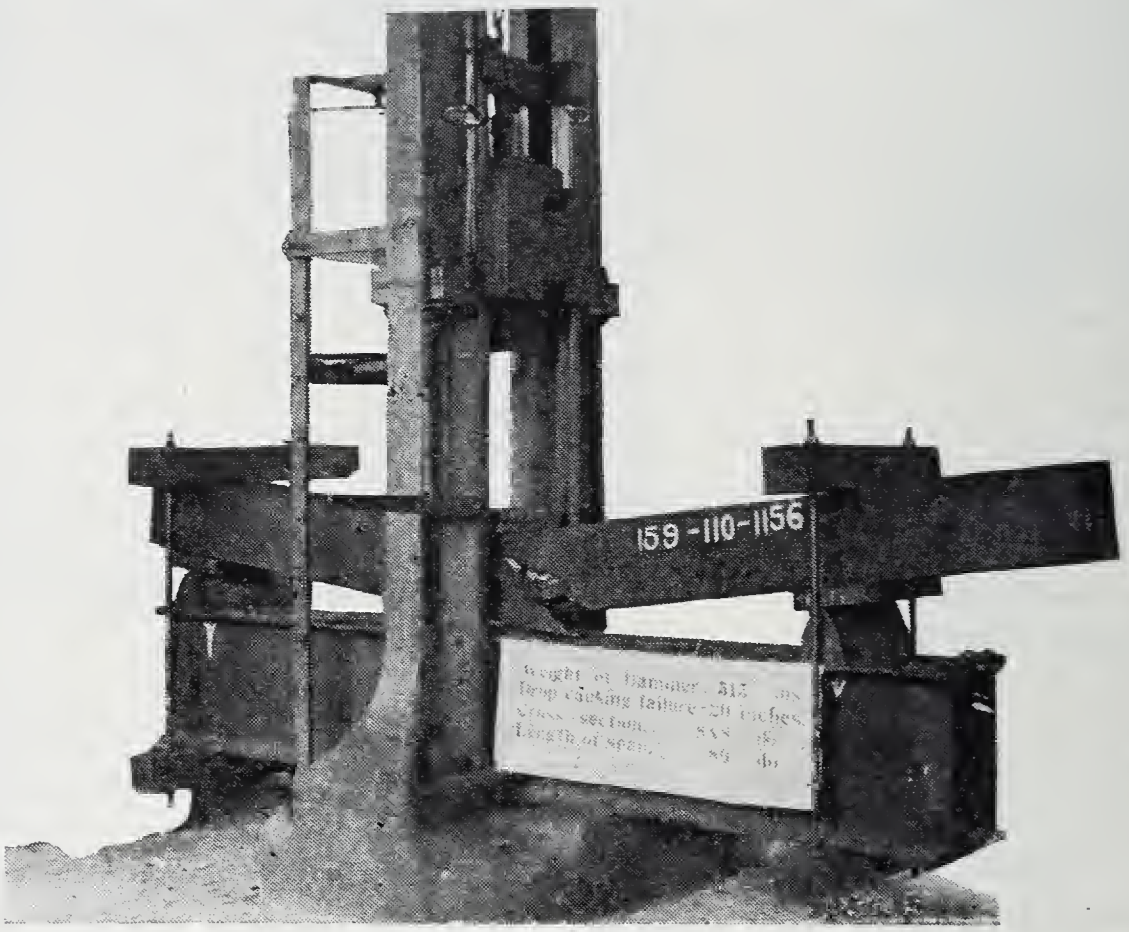


FIG. 10.—Method of Making Impact Test of Bridge Tie.

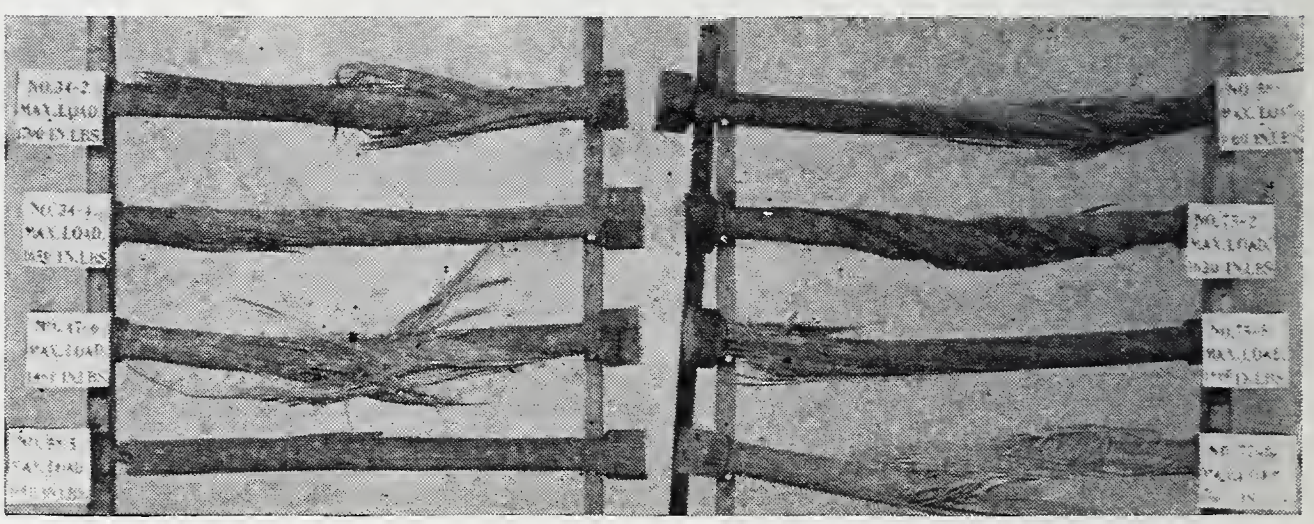


FIG. 11.—Torsion Tests of Soaked Hickory.

METHODS OF TESTING TIMBER

is harder than most hardwoods; but it is only about two-thirds as hard as canyon live oak, the hardest hardwood in the list. Their softness and ease of working make the soft-woods as valuable for many purposes as are the hardwoods for other purposes.

EFFECT OF MOISTURE

The comparative properties of the various species of wood as indicated in the foregoing tables (Tables 2–8) are based upon tests of green timber, which give decidedly different results from tests upon dry timber.

Water occurs in wood in two forms: First, the water which fills the spaces between the cells in green wood; and second, that which saturates the walls of the cells. Often half the weight of green wood, and sometimes more, consists of water. The amount of water required to saturate the walls of the cells is from 25 to 30 per cent of the weight of the wood when absolutely dry. This is called the "fiber saturation point." The amount of water in wood above this point has no effect upon the strength of wood; but, of course, it makes the wood heavier. When wood is dried below the fiber saturation point, its mechanical properties change rapidly, and the extent to which they change depends upon the degree to which the water is removed from the cell walls. Seasoned wood is stronger, stiffer, and harder than green wood. On the other hand, it may not be so tough as green wood, since dry wood is more likely to break than to bend and subsequently regain its form. Small pieces of thoroughly seasoned wood may be twice as strong as pieces of the same wood in green condition. Owing to the checks which frequently develop in the seasoning of large timbers, it is not safe to count upon any such great increase in strength in them as occurs in the seasoning of small timbers. This question is further discussed in the chapter on Structural Timbers.

SHRINKAGE OF WOOD

The amount which wood shrinks in passing from green to dry condition is one of its most important properties.

Shrinkage varies with the kind of timber, degree of seasoning, method of drying, and manner in which the piece is cut from the tree. Quarter-sawed timber shrinks less than slash-sawed; some methods of drying cause much greater shrinkage than others; and, as a class, the softwoods shrink less than the hardwoods. Moreover, shrinkage is chiefly across the grain; that is, a board loses breadth and thickness, but practically nothing in length, when it seasons.

Among softwoods, the cedars and white pines shrink the least. The spruces, firs, and softer pines shrink a medium amount; and longleaf pine and tamarack, the most. Among hardwoods, locust, osage orange, butternut, and black cherry shrink little; ash, elm, and maple, an average amount; and basswood, white oak, birch, and hickory, the most. Because of their more complex structure, the hardwoods also require greater care in seasoning than do the softwoods, to prevent warping and checking.

VARIATIONS IN TIMBER

Before leaving this chapter especial attention should be given to the caution in the opening paragraph on page 10, with respect to the variations in timber. No one should, under any circumstances, use the strength values given in Tables 1–8 in figuring working stresses for construction purposes. Within a wide range of variability these tables are instructive as showing the difference in properties of different woods, but since the figures are based upon comparatively few tests of small clear sticks of green wood, they should not, under any consideration, be used in accurate calculations. A table of recommended working stresses for structural timbers is given on page 95.

Variations in strength within the same species are often found which are greater than the variations between different species. These variations are due to density of the timber, grade, moisture content and kind of test applied. For the sake of accuracy and at the risk of repeating some statements made elsewhere in this volume, we reproduce from the Lumber

World-Review the following article by J. A. Newlin, of the Forest Products Laboratory:

VARIATION IN WEIGHT AND STRENGTH OF TIMBER

Timber is looked upon as an exceedingly variable material without any definite idea as to just what the term ''exceedingly'' implies. It is the purpose of this paper to point out the causes of variability in timber and to give a more definite idea as to the extent to which each cause influences the properties of wood.

In view of the fact that the causes of variation in weight are fewer and the resulting variations different than in the case of strength properties, the two will be considered separately, and the variation in the weight of wood will be taken up first.

Variation in Weight of Wood.—Any piece of wood selected promiscuously may contain anywhere from 4 per cent moisture, as in some kiln dried material, to two times as much moisture by weight as wood material, as in occasional pieces of white fir. In view of this fact it is necessary to divide wood into three groups as to moisture in order to effect a definite comparison. These groups represent a maximum amount of moisture, as in green wood; wood with no moisture, or oven-dry wood; and wood with an intermediate percentage of moisture present, or air-dry wood.

The weight of green wood depends upon the weight of the wood substance itself, the moisture content, and the weight of other contained substances such as resin. The various species contain widely different amounts of moisture in the living tree; for example, white ash and black locust are always comparatively dry; black ash and the oaks have about twice as much moisture, and chestnut and buckeye have three times as much as the white ash; the white ash and red cedars are comparatively dry while cypress and white fir contain large amounts of moisture.

Variations in Moisture Content.—Position in the tree also affects moisture content. Most hardwoods show a fairly uniform distribution of moisture through the tree and the variation in the hardwood species is comparatively small. The conifers, on the other hand, show a wide variation in moisture content. In the same tree, as a rule, a large difference in the percentage of moisture exists between the heart and sapwood and, in some instances, between the upper and lower parts of the tree. Longleaf pine and most other conifers have very low moisture content in the heartwood and very high in the sapwood, causing young thrifty trees to run heavier than old over mature trees of the same species. Tamarack and cypress are exceptions, having fairly uniform moisture contents throughout the tree. Sugar pine and western larch, due to resinous material as well as water, are very heavy at the butt.

Variations of 5 per cent above or below the average weight per cubic foot for a given species are to be expected in the case of species having a fairly uniform moisture content. This variation may, however, run as high as 20 per cent occasionally. With species that do not have a uniform moisture content about 10 per cent variation in the weight per cubic foot may be expected with occasional trees varying as much as 40 per cent. These figures apply when considering small amounts of the wood, such as timber from a single tree. In larger shipments, as would be expected, the average weight is much more likely to be nearer the average value for the species, although in the conifers, as was previously pointed out, the character of the stand would materially influence the weight per cubic foot.

Variations in Time of Drying.—Air-dry weight varies largely on account of the wide variation of moisture content implied by the term. Some species lose the moisture in one-tenth the time of others. Some material is air-dried to reduce its shipping weight and is considered dry when it ceases to lose moisture fairly rapidly, while for some of the more exacting uses the material will be carefully dried for months or even years until it reaches as low a moisture content as possible under the conditions and moisture within the stick has become uniformly distributed. For example, in air-dry telephone poles of cypress the moisture content may be over 40 per cent of the oven-dry weight of the wood, while for high class finish lumber of the same material it will probably be below 10 per cent. Thus it is seen that different conditions of air-drying may affect the weight of a species so that one class of material will be only about three-fourths as heavy as material of another class. However, for any given class of timber the figure is fairly uniform and the weight per cubic foot will have about the same percentage variations as in the green hardwoods.

Variations in Dry Timber.—The weight per cubic foot of absolutely dry, or oven-dry material, varies somewhat less in percentage than the weight of either green or air-dry timber. The timber from any given tree will one-half of the time fall within 4 per cent of the average value with occasional values as much as 16 per cent above or below the average. These variations are about the average for most species. The longleaf pine and Douglas fir, however, show variations about one and one-half times as large as those given.

Variation in Strength Values.—The strength, hardness, stiffness, and shock resisting ability of a given piece of timber are dependent upon the density grade, moisture content, nature of loading, and species.

Variation in density, or oven-dry weight per cubic foot, is one of the chief causes of variations in the mechanical properties of wood. In fact, the relation between density and strength is so definitely known that the density of a wood may well be taken as a criterion of its strength properties. It is found that as a rule all strength properties increase with the density.

Strength and stiffness of a beam or post increase with the first power of the density.

Hardness and strength in compression perpendicular to the grain vary almost exactly with the square of the density, while the shock resisting properties vary by a slightly higher power.

Relations of Grade to Strength.—It is hardly necessary to state that the grade of timber has a marked effect on the strength properties. Checks, knots, ring shakes, and other defects in general result in lower values in all the strength properties. Commercial timber will range all the way from sticks that will barely support their own weight as a beam to clear straight-grained dry timber much stronger in proportion to its weight than structural steel. Difference in grade is responsible for a great deal of the variation in strength of the structural timbers.

Change in moisture content in the approximately green material affects the strength values above listed very little. This is because the moisture contained above the fibre saturation point, usually about 25 per cent or 30 per cent moisture, does not materially affect the mechanical properties of wood. Below this point, however, most of the strength values in small pieces increase rapidly with a decrease in moisture.

Moisture Content and Strength Value.—Hence, in air-dry material moisture content is a very important factor in its effect on strength values. In many instances the ultimate bending strength is more than doubled by a reduction in moisture from the fibre saturation point to 10 per cent or 12 per cent moisture, a condition representative of air-dry material such as small timber stored inside. In impact bending it is found that an increase of about 8 per cent in the ability of a specimen to absorb a shock and return to its original form is caused by a decrease of 1 per cent in moisture when the moisture content is about 12 per cent of the oven-dry weight. However, the total shock a specimen can absorb before complete breakage is found to be greater in the green or wet condition. In other words, a dry piece of timber will spring farther (without being permanently distorted) and return to its original position with a greater force than a green timber of the same material. But when failure starts, the dry timber fails much more quickly than the green. That is, the dry timber is more brash. Stiffness increases with the dryness, but the change is by no means as marked as in the bending strength, a gain of only about 25 per cent being effected by the drop from the fibre saturation point to 10 per cent or 12 per cent moisture.

Although the mechanical properties generally show a marked increase in strength with a decrease in moisture, in structural design allowance should be made for this increase only in rare instances, for the reason that it is a rather indefinite quantity and in structural timbers the defects and checks resulting from seasoning will usually offset any grain in strength due to drying. In addition, most structural timbers are subject to moisture change and are likely at any time to become as wet as in the green state. Consequently, strength values for the green material only should be used.

Duration in Loading.—Two series of tests made under widely different conditions of loading are not comparable because of the variations in

results on this account. The rapidity with which the load is applied and the duration of the load has a marked influence. For instance, it is found in impact bending where the load is applied almost instantaneously a stick will resist without apparent injury a force more than double the dead load which would ultimately cause failure. It has also been determined that a beam loaded over a period of several months will finally break under a load less than two-thirds that required to break it where the ultimate load is reached in a few minutes.

Tests on large pieces will ordinarily show lower strength values than those obtained from small specimens for the reason that the large pieces usually contain defects of one form or another in the region of failure whereas the small ones are clear.

Variations in Bending Strength.—The variation between species is very great when opposite extremes are taken. For example, the bending strength of black willow is about one-fourth that of black locust. But for woods ordinarily competing for the same structural purposes this difference is usually small and has been greatly overestimated, greater differences in strength properties usually existing within these species than between their averages. For instance, 25 per cent of the timber from the true shortleaf pine (pinus echinata), an inferior timber, will average higher in strength values than the average longleaf pine (pinus palustris), one of the best structural timbers; and 25 per cent of the latter will fall below the averages for the former. Thus it is seen that it is just as important, if not more so to inspect the quality of wood in a given shipment as it is to determine the exact species.

In small clear specimens of the same species tested green under the same conditions, variations are largely accounted for by variations in density. Those properties which vary as the higher powers of the density we would expect to have greater variability than those which vary with the first power, and that the variation above the average would be slightly greater than below. This we find to be the case. Strength and stiffness as a beam or post come under the latter head and it is found that in the conifers the probable variation from the average is about 12 per cent. That is, it is an even wager that these values for any single specimen will be either within or without 12 per cent of the average for the species. In exceptional cases a piece may be as much as 48 per cent above or below the average. In the oaks the probable variation is 15 per cent and occasional pieces may go as high as 60 per cent above or below the average.

Hardness and Shock Resistance.—Hardness and compression perpendicular to the grain, varying about as the square of the density, have a somewhat higher probable variation, the figures being 15 per cent for the conifers and 17 per cent for the oaks. Occasional specimens in either class, however, may be found to vary from the average for the species by four times these amounts.

In the case of shock resisting ability, which varies as a somewhat higher power than the square of the density, the probable variation is 18 per cent for the conifers and 24 per cent for the oaks with occasional

pieces varying by as much as four times these amounts from the species average.

In case an average for any of these values is considered as in any given shipment it would, of course, in all probability be nearer the average for the species and the greater the amount considered the closer the average would be expected to approach the true species average.

If small clear specimens of the same species and density and with the same conditions of testing are considered the variation will be found to be comparatively small. Under these conditions the probable variation given above will be reduced by about one-third, leaving a small part of the variation in timber unaccounted for.

Accuracy of Estimates.—Thus it is seen that the strength of timber of a given species with its defects, density, and moisture content known may be estimated with considerable accuracy. No attempt should be made to compare species upon data in which the conditions are not practically the same or where reliable data are not at hand for reducing values to a common basis. With timbers free from defects and of the same species and moisture content only one-fourth of them may be expected to fall more than 12 per cent below the average in strength. Of this one-fourth occasional timbers will have only one-half the average strength. It is the purpose of the density clause in the grading rules for structural timbers to eliminate the relatively small percentage of the timber in which the clear wood has only from one-half to two-thirds the average strength for the species.

CHAPTER III

LUMBER GRADES

Lumber is made a standard commercial product through its separation into grades according to quality and size. The grading of lumber is a commercial necessity for two reasons: First, to make it possible for the manufacturers to maintain a uniformity of production; and second, to adapt the product to the needs of many classes of consumers.

PURPOSE OF GRADING

The aim of a grading system is excellently stated in one of the association rule books as being to make lumber of the same grade of approximately equal value when produced at different points, whether the logs from which the lumber is cut are large or small, coarse-knotted, fine-knotted, black-knotted, red-knotted, sound, or shaky. In other words, the purpose of the system is to enable each manufacturer to classify his product into grades of practically the same value to the customer as are the corresponding grades of lumber made by other manufacturers from the same kind of timber. The advantage to the customer in being thus enabled to obtain a standard product is too obvious to need any discussion.

In the early days of lumbering in the United States, the manufacturer paid little or no attention to grades. In fact, about all that was done was to separate the product into broad classes, known as "merchantable" and "cull" lumber. The former contained lumber of a character fit for general use; the latter, lumber of much poorer quality, which sold for a low price and was fit for little but temporary use or for the manufacture of boxes in the process of which the worst of the defects could be cut out. Under this system, or lack of

system, the dealer purchased large stocks of lumber, and roughly separated them into classes adapted to the needs of his customers.

It was not until the later eighties that the manufacturers of lumber seriously undertook the establishment of a thorough-going system of grades for their products. By that time the annual output of lumber, and especially of white pine, had become so large that the adoption of uniform grades was really a necessity for both producer and consumer. And it was only through the organization of lumber manufacturers in a common territory into an association that standardization of product became possible. The first effective organization of this sort was that of the white pine manufacturers in the upper Mississippi Valley; and the plan which they adopted has been the essential basis upon which nearly all other organizations of lumber manufacturers have been built up.

The first thing the white pine manufacturers did was to agree upon the grades of lumber which should be recognized as standard, and to take measures to make these standards known to both producers and consumers. This required that specifications be carefully drawn and published, and that experts be employed to apply them. The manufacturers therefore organized an inspection bureau composed of experienced lumber graders, whose duty it was to travel from mill to mill, instructing the manufacturers how to conform the product to standard grades. Moreover, these inspectors were sent to reinspect a shipment whenever the buyer complained that the manufacturers did not ship the grades named in the invoice. Work of this kind proved so beneficial that the example spread until, in every large manufacturing region in the United States, there is now an organization which determines the standard grades for each of the principal kinds of lumber, and whose authority in this respect is generally recognized. The development and general acceptance of these grading systems is one of the best examples we have of the growth of commercial usages which for all practical purposes are as binding as legal enactment.

THE BASIS FOR GRADES

Fig. 12.—No. 1 Common Hardwood Board, 8-In., 12-Ft.
Cuts more than 66⅔ per cent clear in three pieces

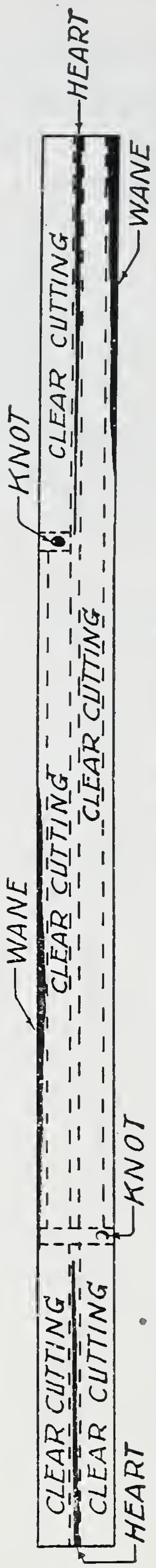


Fig. 13.—No. 2 Common Hardwood Board, 8-In., 14-Ft.
Cuts 50 per cent clear in five pieces

Lumber is separated into grades on the basis of the defects which it contains; and the first step in the formulation of a grading system is to define the admissible defects. Defects usually recognized are: knots, knot-holes, shake, wane, rot, stain, etc. Poor manufacture is also a defect; and grading rules generally require that lumber must be properly manufactured, with parallel edges and square ends.

In the determination of lumber grades, two general classes of usage are considered: First, those in which the lumber is used in its entirety; and second, those in which the lumber is cut to new dimensions in the process of re-working into other products. Into the first class falls the larger proportion of the softwood lumber used for general construction. Dimension, for example, is used for studding, joists, sills, rafters, etc.; and boards are used for siding, sheathing, roof-boards, partitions, and the like. In either case, the lumber is used in essentially the form and size in which it is first manufactured; and the grades provided for it require that the defects shall not be of such character or in such quantity as to impair the

usefulness of the piece as a whole. In other words, a piece of dimension may contain knots, shake, pitch streaks, or decay; but these defects must not be so located or so numerous as to render the piece too weak to be used for studding, joists, and similar purposes.

The cutting grades of lumber find their largest use in factories where they are cut to smaller dimensions and re-worked into a multitude of articles, such as furniture, sash, doors, interior finish, packing boxes, etc. Many of the products of these factories contain only sound, clear lumber when finished; but, since the lumber is cut into very different sizes from those in which it was originally manufactured, it is possible to cut out the portions which contain knots, rot, and other defects, and to obtain clear, sound pieces of the sizes needed for the finished articles. A common requirement in grades of this sort, therefore, is that a certain grade of lumber must contain a specified percentage of clear stock in sections of specified sizes. For example, the grade of No. 1 Shop Common in white pine must contain not less than 50 per cent nor more than 70 per cent of cuttings suitable for use in the manufacture of doors, these cuttings to be of specified lengths and widths. Again, the rules of the National Hardwood Lumber Association require that the grade of No. 1 Common must contain clear stock in pieces 3 and 4 inches wide and 6 and 7 feet long; and that the larger boards of this grade must be of a character which will permit their being cut into a certain number of clear pieces equivalent in total size to two-thirds the area of the original board.

PRINCIPAL SYSTEMS OF GRADING

The principal associations of lumber manufacturers in the United States which have adopted standard grading rules for their products and for the woods which the members of each organization chiefly manufacture, are as follows:

California Redwood Association, San Francisco, Cal.—Redwood.

California White and Sugar Pine Association, San Francisco, Cal.—Sugar pine, California white pine.

Georgia-Florida Sawmill Association, Jacksonville, Fla.—Yellow pine (chiefly longleaf, shortleaf, and Cuban pine).

Hardwood Manufacturers Institute, Chicago, Ill.—Ash, basswood, beech, buckeye, butternut, cherry, chestnut, cottonwood, elm, gum, hickory, maple, walnut, oak, poplar, sycamore, tupelo.

Maple Flooring Manufacturers Association, Chicago, Ill.—Maple, beech, and birch flooring.

Michigan Hardwood Manufacturers Association, Cadillac, Mich. —Hemlock. Hardwood rules the same as the National Hardwood Lumber Association.

National Hardwood Lumber Association, Chicago, Ill.—Ash, basswood, beech, birch, buckeye, butternut, cherry, chestnut, cottonwood, sassafras, elm, gum, hickory, locust, magnolia, maple, oak, pecan, poplar, sycamore, walnut.

Northern Hemlock and Hardwood Manufacturers Association, Oshkosh, Wis.—Hemlock. Hardwood rules the same as the National Hardwood Lumber Association.

Northern Pine Manufacturers Association, Minneapolis, Minn.—White pine, Norway pine, spruce, tamarack.

North Carolina Pine Association, Norfolk, Va.—North Carolina pine (mostly loblolly; some shortleaf pine).

Oak Flooring Manufacturers Association, Chicago, Ill.—Oak flooring.

Southern Cypress Manufacturers Association, New Orleans, La. —Cypress, tupelo.

Southern Pine Association, New Orleans, La.—Longleaf pine, shortleaf pine.

West Coast Lumbermen's Association, Seattle, Wash.—Douglas fir, Western spruce, cedar, and hemlock.

Western Pine Manufacturers Association, Portland, Ore.—Western pine, Idaho white pine, fir, and larch.

Copies of their complete grading rules are supplied by these associations upon application, free of charge by some and by others at a nominal price. The associations are generally anxious to make their grades as widely known and used as possible.

Diversity of Grades.—A few illustrations will suffice to show the extent to which the lumber manufacturers have gone in establishing grades suitable for a wide diversity of purposes. The rules of the Northern Pine Manufacturers Association provide for 7 grades of thick finishing lumber in thicknesses of 1¼ inches, 1½ inches, and 2 inches. There are also 8 grades of inch finishing lumber, 5 grades of siding and flooring, 3 grades of shiplap, 4 grades of shop lumber, 3 grades of factory select lumber, 6 grades of thick common lumber, 5 grades of

common boards, 4 grades of fencing, 3 grades of dimension, and 2 grades of lath. Under these rules the upper grades in the various classes are designated by letters as A, B, C, D, and the lower grades by numerals as No. 1, No. 2, No. 3, and and No. 5.

The rules for hardwoods adopted by the National Hardwood Lumber Association and the Hardwood Manufacturers Institute provide in most cases for the following grades, beginning with the highest: Firsts and Seconds, Selects, No. 1 Common, No. 2 Common, and No. 3 Common. No. 4 Common is also provided for many woods. In addition to these general grades, there are a large number of special grades for the various hardwoods, covering box lumber, vehicles and wagon stock, furniture stock, flooring stock, quarter-sawed lumber, panel material, etc.

In the softwoods most largely used for general building purposes, there are usually three grades of common lumber generally known as No. 1, No. 2, and No. 3, or by terms of equivalent value. For example: No. 1 Dimension, Boards, etc., consist of sound, strong lumber suitable for first-class, all-round building purposes. The defects allowed in this lumber are not of a character which will materially impair the strength of the piece for the purpose intended. No. 2 stock contains more defects than No. 1, but is useful for the same general purposes in places where less strength is required. For example, studding of No. 2 Dimension is often as satisfactory as of No. 1 Dimension, while No. 2 Boards make excellent sheathing, under-floors, roof-boards, etc. The No. 3 stock in dimension and boards is the lowest grade generally used for building purposes. It is mostly employed for very cheap, light, or temporary structures, and for these purposes affords a very economical building material.

Special grades in any item are put up by the manufacturers whenever ordered; but they cost more than regular grades, depending upon quality and handling charges.

Any large user of lumber will be well repaid if he familiarizes himself with the principal grades of the leading kinds of timber. By so doing he will be able to build better and more cheaply than if he specifies material without a full knowledge of its character and value.

CHAPTER IV

STANDARD SIZES OF LUMBER

As there were no well-defined grades in the early lumber manufacturing operations, so also was there little uniformity in the sizes to which the various classes of lumber were cut. In the early days, boards and larger material were shipped in the rough to planing mills at points of consumption, where they were dressed and worked to the desired sizes. With the development of the lumber industry and the greatly increased variety and efficiency of machinery, the manufacturers gradually began to work their products into forms suitable for final use. This process has gone on until to-day nearly every large sawmill which supplies car trade has a fully equipped planing mill in which lumber is dressed and worked into flooring, ceiling, shiplap, siding, partition, molding, etc., so that a practically complete bill of materials for a house can be shipped from the mill.

This advance in the development of lumber manufacturing makes the question of standard sizes as important as that of standard grades. In fact, the two naturally go hand in hand; and specifications for widths and thicknesses of dressed lumber are commonly a part of the grading rules of the associations of manufacturers.

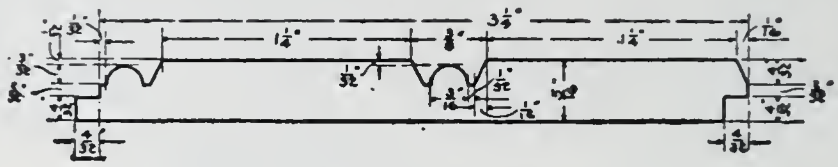
There is some variation, according to species, in the lengths and widths of rough lumber made in the sawmills. Since the softwoods are the more common structural material, and hence used in the entire piece, the dimensions vary somewhat from those of the hardwoods, of which the bulk are cut to new sizes in the process of re-manufacturing. The standard lengths of softwoods are commonly in multiples of 2 feet, beginning at 4 or 6 feet; and standard widths, in multiples of 2 inches, beginning at 4 inches. This is upon the theory that these dimensions are best adapted to the requirements of ordinary

building operations for the placing of studding, joists, etc. In the hardwoods, standard lengths are usually in both odd and even feet, and standard widths in both odd and even inches. The most notable exception to these rules is in the manufacture of hardwood flooring, in which dimensions as small as 1 inch in width, 7 inches in length, and 3/8 inch in thickness are produced.

While each association of lumber manufacturers has standards for working lumber, which are recognized within its territory, these standards frequently do not coincide with the standards of other associations. There is a much greater diversity in this respect than is desirable from the standpoint of the consumer; and doubtless in time, a greater uniformity will be brought about in standard sizes for all the more common kinds of lumber since steps toward this end have been initiated. The present standards for flooring, ceiling, shiplap, partition, boards, etc., for the principal commercial woods, are given in Table 10, in which the nominal dimension is named, together with the actual size of the finished product. The nominal dimension is the size which is figured in calculating the quantity of lumber sold, and is based upon rough stock; while the actual dimension indicates the actual width and thickness of the final product. For example, a piece of 1x4 Norway pine flooring is 25/32 inch thick, with 3¼-inch face. That is, allowing for tongue and groove, each piece of flooring covers 3¼ inches of floor space. Since it is important that the user of lumber should know the exact sizes specified for the principal woods, the table is made as complete as the information at hand permits. In several cases where standard sizes have not been officially incorporated in association rules, the sizes made by the leading manufacturers are given.

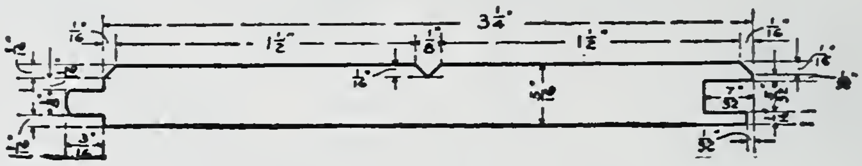
Standard Sizes and Patterns of Yellow Pine Ceiling

⅜-inch Ceiling, Shiplapped.



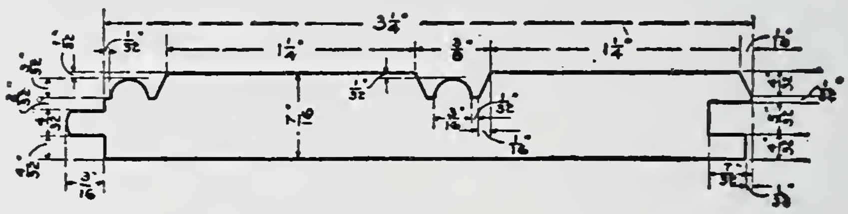
⅜-inch Ceiling, Shiplapped

⅜-inch Ceiling, D. & M.



⅜-inch Ceiling, D. & M.

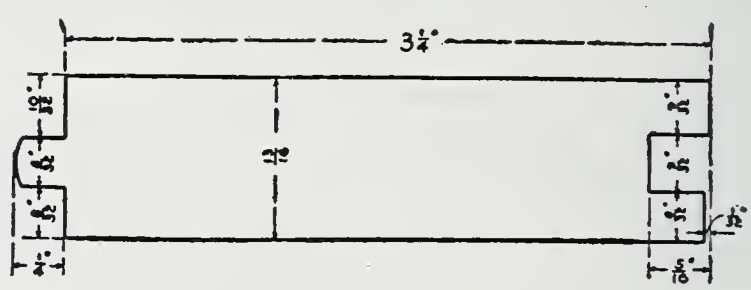
½-inch Ceiling.



½-inch Ceiling

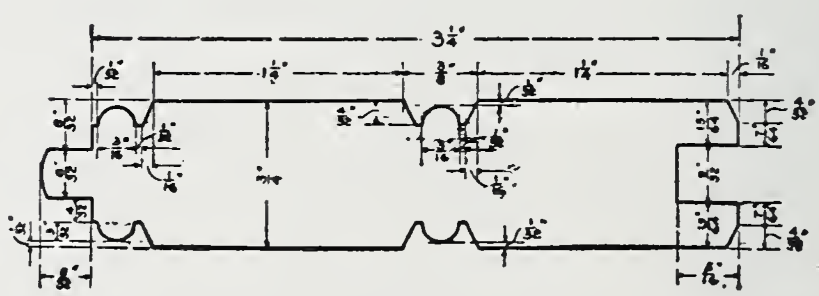
Standard Sizes of Yellow Pine Flooring and Partition

1 x 4 Flooring.



1×4 Flooring

1 x 4 Partition.



1×4 Partition

Fig. 14.—Standard Patterns.

(Southern Pine Association)

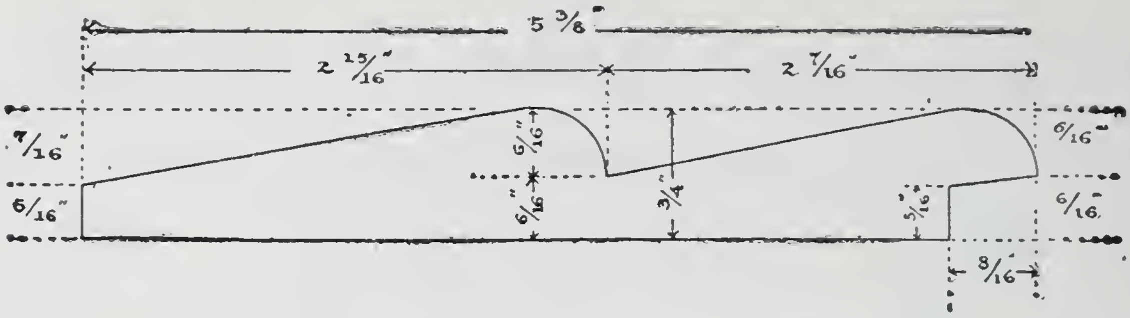
TABLE 10

Standard Sizes of Different Kinds of Lumber

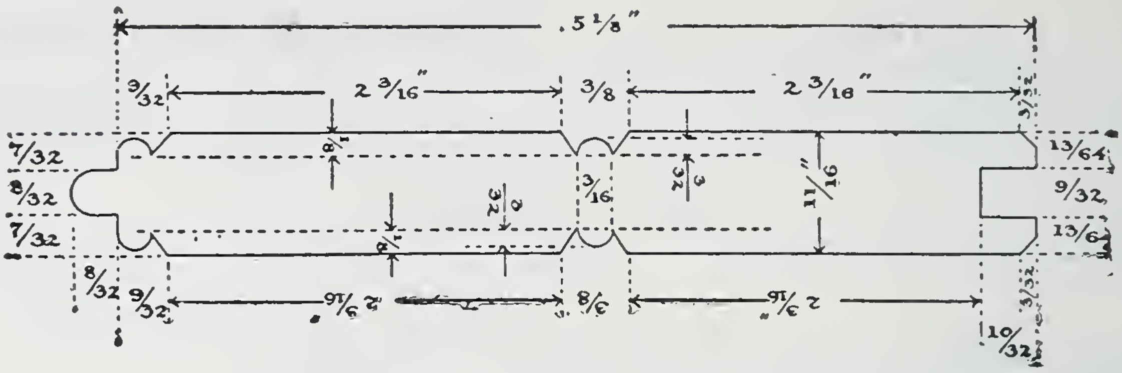
FLOORING (INCH)

F=Face. Width and thickness of tongue is ¼ inch, and dimensions of groove 1/32 inch greater.

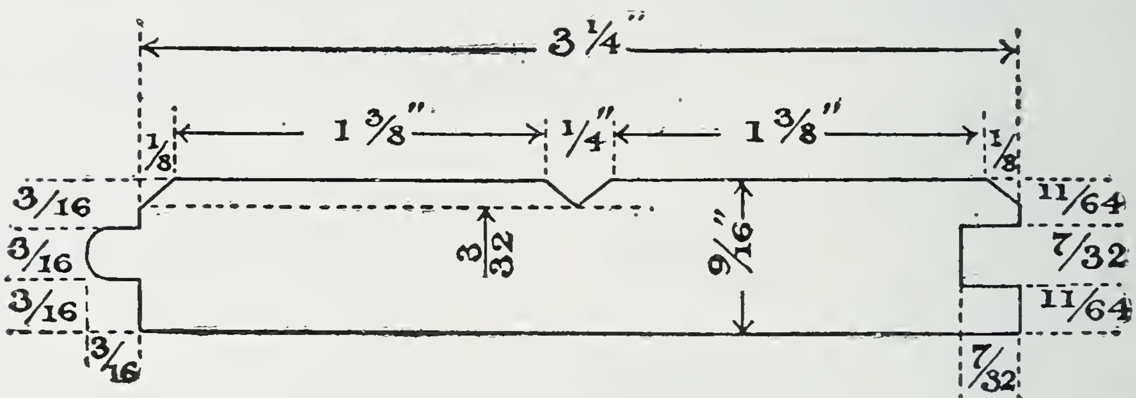
Woods	Thickness and Width (Inches)
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	1x4 is 25/32x3¼ F; 1x6 is 25/32 x5¼ F.
North Carolina Pine (North Car. Pine Ass'n)	1x3 is 13/16x2¼ F; 1x4 is 13/16 x3¼ F; 1x6 is 13/16x5¼ F.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	1x3 is 13/16x2⅜ F; 1x4 is 13/16 x3¼ F; 1x6 is 13/16x5¼ F.
Longleaf and Shortleaf Pine (Southern Pine Ass'n)	1x3 is 13/16x2⅜ F; 1x4 is 13/16 x3¼ F; 1x6 is 13/16x5¼ F.
Cypress and Tupelo (So. Cypress Mfrs. Ass'n)	1x3 is 13/16x2¼ F; 1x4 is 13/16 x3¼ F; 1x6 is 13/16x5¼ F.
Douglas Fir, Western Hemlock, Cedar, and Spruce (West Coast Lumbermen's Ass'n)	1x3 is 13/16x2¼ F; 1x4 is 13/16 x3¼ F; 1x6 is 13/16x5⅛ F.
Oak (Oak Flooring Mfrs. Ass'n)	13/16x1½, 2, or 2¼ F; ⅜x1½ or 2 F.
Maple, Beech, and Birch (Maple Flooring Mfrs. Ass'n)	Thicknesses—⅜, ½, ⅝, 13/16, 1 1/16, 1 5/16, 1 11/16. Faces—1½, 2, 2¼, 3½, 4.
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	1x4 is 25/32x3¼ F; 1x6 is 25/32 x5¼ F.
Idaho White Pine, Western Pine, Fir, and Larch (Western Pine Mfrs. Ass'n)	1x4 is 25/32x3¼ F; 1x6 is 25/32 x5¼ F.



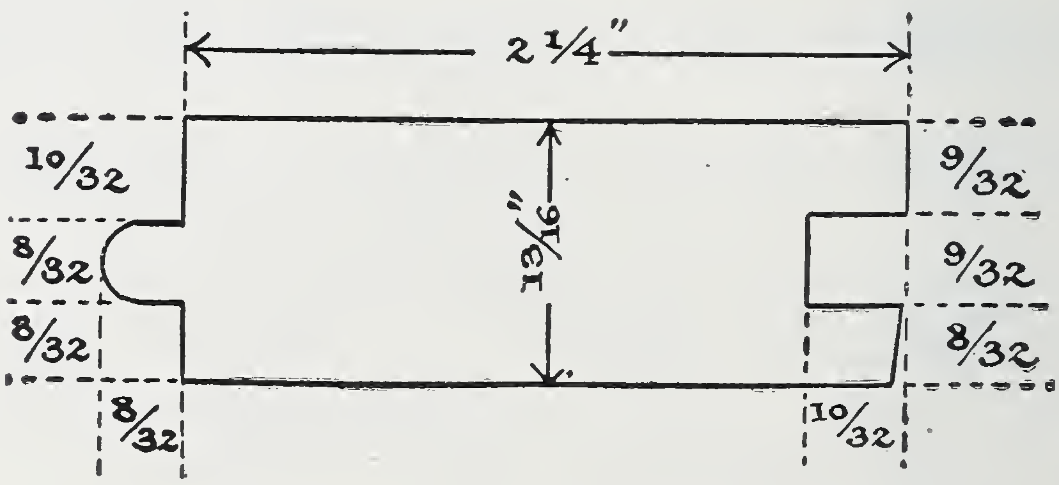
"Novelty Rustic" Siding, 1"×6", No. 117 (Standard)



Double-Beaded Ceiling or Partition



Double V Ceiling, 5/8"×4" (Standard)



Vertical-Grain Flooring, 1"×3" (Standard)

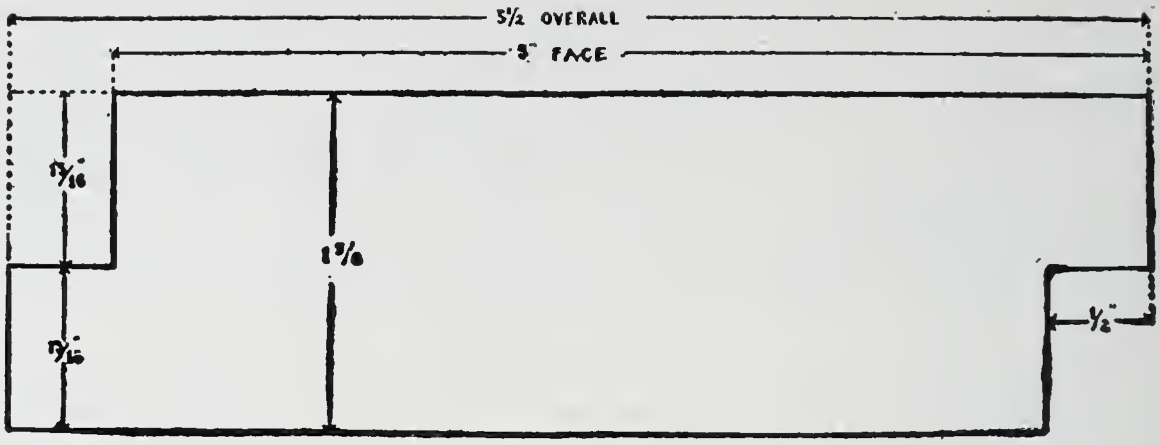
Fig. 15.—Standard Patterns.

(West Coast Lumbermen's Association)

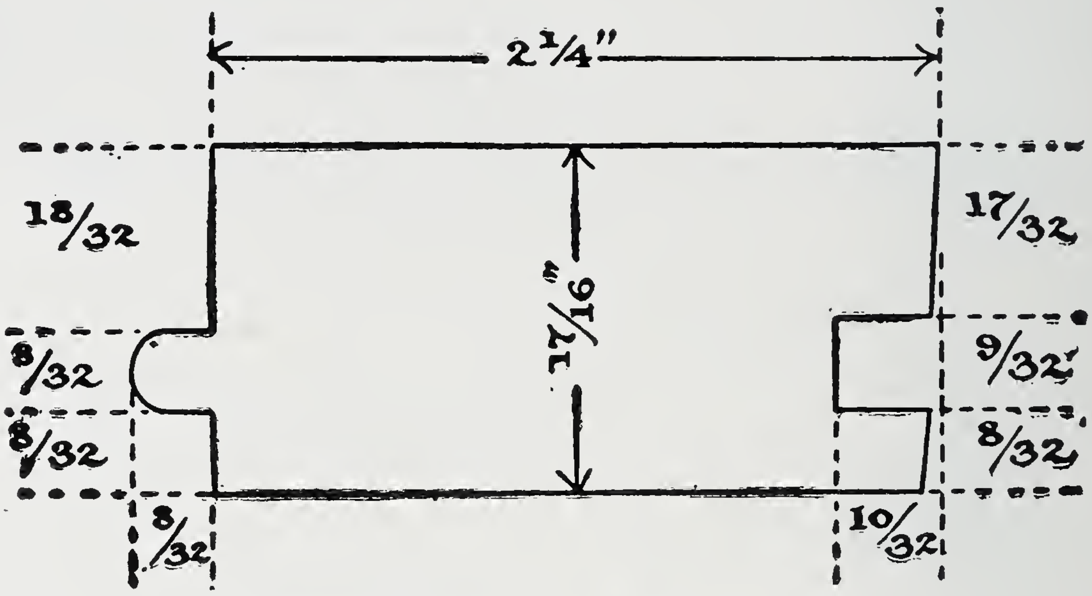
CEILING (INCH)

Woods	Thickness and Width (Inches)
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	1x4 is 25/32x3¼ F; 1x6 is 25/32 x5¼ F.
North Carolina Pine (North Car. Pine Ass'n)	1x4 is ⅝x3¼ F; 1x6 is ⅝x5¼ F.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	¾x4 is 7/16x3¼ F; ¾x6 is 11/16 x5¼ F.
Longleaf and Shortleaf Pine (Southern Pine Ass'n)	¾x4 is 7/16x3¼ F; ¾x6 is 11/16 x5¼ F.
Cypress and Tupelo (So. Cypress Mfrs. Ass'n)	¾x4 is 7/16x3¼ F; ¾x6 is 11/16 x5¼ F.
Douglas Fir, Western Hemlock, Cedar, and Spruce (West Coast Lumbermen's Ass'n)	1x4 is 7/16x3¼ F; 1x6 is 11/16 x5⅛ F.
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	1x4 is 25/32x3¼ F; 1x6 is 25/32 x5¼ F.
Northern Hardwoods (Mich. Hdw. Mfrs. Ass'n)	1x4 is 13/16x3¼ F; 1x6 is 13/16 x5¼ F.
Idaho White Pine, Western Pine, Fir, and Larch (West. Pine Mfrs. Ass'n)	1x4 is 25/32x3¼ F; 1x6 is 25/32 x5¼ F; 1x8 is ¾x7⅛ F.
Redwood	1x4 is ¾x3¼ F; 1x6 is ¾x5¼ F.
Gum (Natl. Hwd. Lbr. Ass'n)	¾x3 is 13/16x2¼ F; ¾x4 is 13/16 x3¼ F; ¾x5 is 13/16x5¼ F; ¾ x6 is 13/16x5¼ F.
Yellow Poplar (Natl. Hwd. Lbr. Ass'n)	Same as Flooring.

Tongues and grooves in inch Ceiling are usually of same dimensions as in inch Flooring. Ceiling is also often made in so-called thicknesses of ⅜, ½, and ⅝ inch, corresponding to dressed thicknesses of 5/16, 7/16, and 9/16 inch, respectively.



Heavy Yellow Pine Shiplap
(Southern Pine Association)



Vertical-Grain Flooring, 1¼"×3" (Standard)
(West Coast Lumbermen's Association)

FIG. 16.—Standard Patterns.

PARTITION (INCH)

Woods	Thickness and Width (Inches)
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	1x4 is 25/32x3¼ F; 1x6 is 25/32 x5¼ F.
North Carolina Pine (Nor. Car. Pine Mfrs. Ass'n) ...	1x4 is ¾x3¼ F; 1x6 is ¾x5¼ F.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	1x4 is ¾x3¼ F; 1x6 is ¾x5¼ F.
Longleaf and Shortleaf Pine (Southern Pine Ass'n)	Same as above.
Cypress and Tupelo (So. Cypress Mfrs. Ass'n)	1x3 is 5/16x2¼ F; 1x4 is 7/16x3¼ F; 1x6 is 11/16x5¼ F.

Patterns of Yellow Pine Drop Siding

Adopted at Memphis, Tenn., Jan. 16, 1901

Revised at New Orleans, La., April, 1915

Worked Shiplap—$\frac{3}{4} \times 5\frac{1}{2}$ over all; allow $\frac{1}{2}$ in. for Lap.

Worked Tongue groove—$\frac{3}{4} \times 5\frac{1}{2}$ over all; $5\frac{1}{4}$ in. Face.

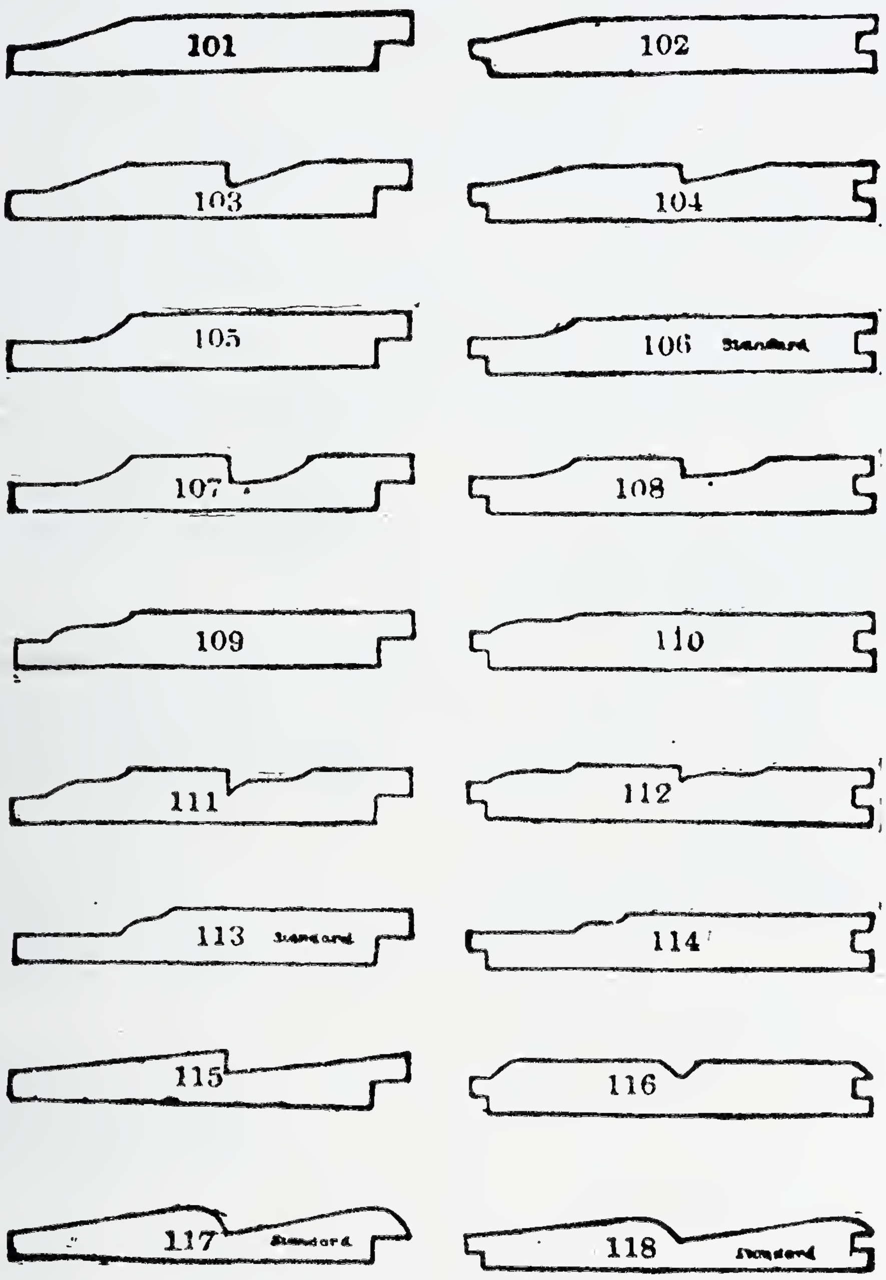


Fig. 17.

Note: With the exception of Nos. 117 and 118, the above patterns are similar in style to the "Universal" Patterns of Drop Siding and Shiplap used by the manufacturers of Northern Pine and Hemlock.

PARTITION (INCH)—*Continued*

Woods	Thickness and Width (Inches)
Douglas Fir, Western Hemlock, Cedar and Spruce (West Coast Lumbermen's Ass'n)	1x4 is ¾x3¼ F; 1x6 is ¾x5⅛ F.
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	1x4 is ¾x3¼ F; 1x6 is ¾x5¼ F.
Gum and Yellow Poplar (Natl. Hwd. Lbr. Ass'n)	Same as Flooring.

DROP SIDING (INCH)

White and Norway Pine (Nor. Pine. Mfrs. Ass'n)	1x4 is 25/32x3¼ F; 1x6 is 25/32 x5¼ F; 1x8 is 25/32x7¼ F.
North Carolina Pine (Nor. Car. Pine Ass'n)	1x4 is 13/16x3¼ F; 1x6 is 13/16 x5½ F.
Longleaf Pine (Ga. Fla. Sawmill Ass'n)	1x4 is 3¼x3¼ F; 1x6 is ¾x5¼ F.
Longleaf and Shortleaf Pine (Southern Pine Ass'n)	Same as above.
Cypress and Tupelo (So. Cypress Mfrs. Ass'n)	1x4 is 13/16x3¼ F; 1x6 is 13/16 x5¼ F; 1x8 is 13/16x7¼ F.
Douglas Fir, Western Hemlock, Cedar and Spruce (West Coast Lumbermen's Ass'n)	1x4 is 9/16x3¼ F; 1x6 is ¾x5⅛ F; 1x8 is ¾x7 F.
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	1x4 is 25/32x3¼ F; 1x6 is 25/32 x5¼ F; 1x8 is 25/32x7¼ F.
Northern Hardwoods (Mich. Hdw. Mfrs. Ass'n)	1x4 is 13/16x3¼ F; 1x6 is 13/16 5¼ F.
Idaho White Pine, Western Pine, Fir and Larch (West. Pine Mfrs. Ass'n)	1x4 is 25/32x3¼ F; 1x6 is25/32x 5¼ F; 1x8 is 25/32x7⅛ F.
Redwood	1x4 is 13/16x3¼ F; 1x6 is 13/16 x5¼ F; 1x8 is 13/16x7¼ F.
Yellow Poplar (Natl. Hwd. Lbr. Ass'n)	1x4 is ¾x3¼ F; 1x5 is ¾x4¼ F; 1x6 is ¾x5¼ F.

FINISH S-1-S OR S-2-S

S-1-S = Surfaced one side; S-2-S = Surfaced two sides

Woods	Widths
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	1″ is 25/32″; 1¼″ is 1⅛″; 1½″ is 1⅜″; 2″ is 1¾″.
North Carolina Pine (Nor. Car. Pine Ass'n)	1″ is 13/16″; 1¼″ is 1 1/16″; 1½″ is 1¼″; 2″ is 1¾″.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	1″ is 13/16″; 1¼″ is 1 1/16″; 1½″ is 1 5/16″; 2″ is 1⅝″.
Longleaf and Shortleaf Pine (Southern Pine Ass'n)	Same as above.
Cypress and Tupelo (So. Cypress Mfrs. Ass'n)	1″ is 13/16″; 1¼″ is 1⅛″; 1½″ is 1⅜″; 2″ is 1¾″.
Douglas Fir, Western Hemlock, Cedar and Spruce (West Coast Lumbermen's Ass'n)	1″ is ¾″; 1¼″ is 1 1/16″; 1½″ is 1 5/16″; 2″ is 1¾″.
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	1″ is 25/32; 2″ is 1⅝″.
Idaho White Pine, Western Pine, Fir and Larch (Western Pine Mfrs. Ass'n)	1″ is 25/32″; 1¼″ is 1⅛″; 1½″ is 1 5/16″; 2″ is 1¾″.
Redwood	1″, 1¼″, 1½″, and 2″ are 3/16″ scant for S-1-S and ¼″ scant for S-2-S.
Gum and Yellow Poplar (Natl. Hwd. Lbr. Ass'n)	1″ is 13/16″; 1¼ is 1 3/32″; 2″ is 1¾″; 2½″ is 2¼″.

FINISH S-1-E OR S-2-E

S-1-E = Surfaced one edge; S-2-E = Surfaced two edges.

Woods	Widths
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	4″ is 3½″; 6″ is 5½″.
North Carolina Pine (Nor. Car. Pine Ass'n)	4″ is 3⅝″; 6″ is 5⅝″; 8″ is 7½″; 10″ is 9½″; 12″ is 11½″.

FINISH S-1-E OR S-2-E—*Continued*

Woods	Widths
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	4″ is 3½″; 6″ is 5½″; 8″ is 7½″ 10″ is 9½″; 12″ is 11¼″.
Longleaf and Shortleaf Pine (Southern Pine Ass'n)	4″ is 3⅝″; 6″ is 5⅝″; 8″ is 7½″; 10″ is 9½″; 12″ is 11½″.
Cypress and Tupelo (So. Cypress Mfrs. Ass'n)	4″ is 3½″; 6″ is 5½″; 8″ is 7½″; 10″ is 9½″; 12″ is 11½″.
Douglas Fir, Western Hemlock, Cedar and Spruce (West Coast Lumbermen's Ass'n)	4″ is 3½″; 6″ is 5″; 8″ is 7¼″; 10″ is 9¼″; 12″ is 11¼″.
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	4″ is 3⅝″; 6″ is 5⅝″; 8″ is 7⅝″.
Idaho White Pine, Western Pine, Fir and Larch (West. Pine Mfrs. Ass'n)	½″ scant.
Redwood	½″ scant.
Gum and Yellow Poplar (Natl. Hwd. Lbr. Ass'n)	½″ scant.

SHIPLAP (INCH)

Woods	Thickness and Width (Inches)
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	1x6 is 25/32x5; 1x8 is 25/32x7 F; 1x10 is 25/32x9 F; 1x12 is 25/32 x11 F.
North Carolina Pine (Nor. Car. Pine Ass'n)	1x6 is ¾x5⅛ F; 1x10 is ¾x11⅛.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	1x8 is ¾x7⅛ F; 1x10 is ¾x9⅛ F; 1x12 is ¾x11⅛.
Longleaf and Shortleaf Pine (Southern Pine Ass'n)	1x6 is 1x5; 1x8 is 1x7⅛ F; 1x8 is ¾ x7⅛; 1x10 is ¾x9⅛ F; 1x12 is ¾x11⅛ F.
Cypress and Tupelo (So. Cypress Mfrs. Ass'n)	1x8 is 13/16x7 F; 1x10 is 13/16x9 F; 1x12 is 13/16x11 F.

SHIPLAP (INCH)—*Continued*

Woods	Thickness and Width (Inches)
Douglas Fir, Western Hemlock, Cedar and Spruce (West Coast Lumbermen's Ass'n)	1x6 is ¾x5; 1x8 is ¾x7 F; 1x10 is ¾x9 F; 1x12 is ¾x11 F.
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	1x6 is 25/32x5¼.
Idaho White Pine, Western Pine, Fir and Larch (West. Pine Mfrs. Ass'n)	1x8 is 25/32x7 F; 1x10 is 25/32x9 F; 1x12 is 25/32x11 F.
Redwood	1x4 is ¾x3; 1x6 is ¾x5; 1x8 is ¾x7; 1x12 is ¾x11.

BOARDS (INCH)

Woods	Thickness
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	S-1-S or S-2-S to 25/32″.
North Carolina Pine (Nor. Car. Pine Ass'n)	S-1-S to ⅞″, S-2-S to 13/16″.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	S-1-S or S-2-S to 13/16″.
Longleaf and Shortleaf Pine (Southern Pine Ass'n)	Same as above.
Cypress (So. Cypress Mfrs. Ass'n)	Same as above.
Douglas Fir, Western Hemlock, Cedar and Spruce (West Coast Lumbermen's Ass'n)	S-1-S or S-2-S to ¾″.
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n; Mich. Hdw. Mfrs. Ass'n)	S-1-S or S-2-S to 25/32″.
Redwood	S-2-S to 13/16″.
Sugar and California White Pine	S-2-S to 13/16″.
Eastern Hardwoods (Natl. Hwd. Lbr. Ass'n)	S-2-S to 13/16″.

DIMENSION (2-INCH, S-1-S-1-E)

S-1-S-1-E = Surfaced one side and one edge.

Woods	Thickness and Width (Inches)
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	2x4, 6, 8, 10 and 12, S-1-S-1-E to 1 9/16x3⅝, 5⅝, 7⅝, 9⅝, and 11⅝.
North Carolina Pine (Nor. Car. Pine Ass'n)	2x4, 6, 8, 10 and 12, S-1-S-1-E to 1⅝x3⅝, 5⅝, 7½, 9½, and 11½.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	2x4, 6, 8, 10 and 12, S-1-S-1-E to 1⅝x3⅝, 5⅝, 7½, 9½, and 11½.
Cypress (So. Cypress Mfrs. Ass'n)	2x4, 6, 8, 10 and 12, S-1-S-1-E to 1¾x3⅝, 5⅝, 7⅝, 9⅝, and 11⅝.
Longleaf and Shortleaf Pine (Southern Pine Ass'n)	2x4, 6, 8, 10 and 12, S-1-S-1-E to 1⅝x3⅝, 5⅝, 7½, 9½, and 11½.
Douglas Fir and Western Hemlock (West Coast Lumbermen's Ass'n)	2x4, 6, 8, 10 and 12, S-1-S-1-E to 1⅝x3⅝, 5⅝, 7½, 9½, and 11½.
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	2x4, 6, 8, 10 and 12, S-1-S-1-E to 1⅝x3⅝, 5⅝, 7⅝, 9⅝, and 11⅝.
Idaho White Pine, Western Pine, Fir and Larch (West. Pine Mfrs. Ass'n)	2x4, 6, 8, 10, 12 and 14, S-1-S-1-E to 1⅝x3⅝, 5½, 7½, 9½, 11½ and 13½.
Redwood	2x4, 5, 6, 8, 10, and 12 to 1¾x3½, 4½, 5½, 7½, 9½, and 11½.

DIMENSION (3-INCH, S-1-S OR S-2-S)

Woods	Thickness
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	S-1-S or S-2-S to 2 9/16".
North Carolina Pine (Nor. Car. Pine Ass'n)	S-1-S or S-2-S to 2¾".
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	S-1-S or S-2-S to 2½" (green).
Longleaf and Shortleaf Pine (Southern Pine Ass'n)	S-1-S to 2¾"; S-2-S to 2½".
Cypress (So. Cypress Mfrs. Ass'n)	S-1-S or S-2-S to 2¾".
Douglas Fir and Western Hemlock (West Coast Lumbermen's Ass'n)	S-1-S or S-2-S to 2½".
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	S-1-S or S-2-S to 2⅝".
Western Pine, Fir and Larch (West. Pine Mfrs. Ass'n)	S-1-S or S-2-S to 2½".

HARDWOOD SIZES

The standard sizes adopted by the National Hardwood Lumber Association are as follows:

Standard Lengths.—Standard lengths are 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16 feet; but not over 15 per cent of odd lengths are admitted.

In the grade of Firsts and Seconds the lengths are 8 to 16 feet; but there must not be more than 20 per cent under 12 feet, and not to exceed 10 per cent of 8 and 9-feet lengths.

Standard Thicknesses.—The standard thicknesses of hardwood lumber are: ¼, ⅜, ½, ⅝, ¾, 1, 1¼, 1½, 1¾, 2, 2½, 3, 3½, 4, 4½, 5, 5½, and 6 inches.

The standard thicknesses for surfaced lumber are as follows:

Rough	Surfaced	Rough	Surfaced
⅜" S-2-S to	3/16"	1¾" S-2-S to	1½"
½" S-2-S to	5/16"	2" S-2-S to	1¾"
⅝" S-2-S to	7/16"	2½" S-2-S to	2¼"
¾" S-2-S to	9/16"	3" S-2-S to	2¾"
1" S-2-S to	13/16"	3½" S-2-S to	3¼"
1¼" S-2-S to	1 3/32"	4" S-2-S to	3¾"
1½" S-2-S to	1 11/32"		

Lumber surfaced one side only must be 1/16 inch full of the above thicknesses.

Movement for Standardization.—Efforts have been made during the last few years to simplify and standardize grades and sizes as well as the names employed for lumber products and by so doing promote efficiency and economy. Impetus was given the movement by the United States Department of Commerce in May, 1922, under whose auspices was held a meeting of representatives of manufacturers, distributors, and consumers, together with these of national organizations of architects, engineers, and railroads. Out of that general meeting and subsequent meetings was evolved a central committee on lumber standards which is working steadily toward the goal of standard grades for softwoods and hardwoods and uniformity of grade names. The proposal has been made so far as size standards are concerned for a standard thickness of 1-inch finish and boards, surfaced two sides, as 25/32-inch; for nominal 2-inch surfaced dimension as $1\frac{5}{8}$-inch. The finished widths proposed are for $\frac{3}{8}$-inch off on widths 4 to 7 inches inclusive, and $\frac{1}{2}$-inch off on widths 8 to 12 inches inclusive.

CHAPTER V

LUMBER AND LOG MEASUREMENTS

Board Measure.—The primary unit of lumber measurement is the board foot, the equivalent of a piece of lumber 1 inch thick, 12 inches wide and 1 foot long, in other words, a square foot of lumber 1 inch thick. In small retail transactions lumber is to some extent sold at so much per board foot, or occasionally by the piece, but the general custom in the lumber trade is to buy and sell at a stated price per thousand board feet, and all ordinary quotations of lumber values are upon the basis of the larger unit.

The number of board feet in pieces of lumber of the more common sizes is shown in the table on page 62. Sizes which are not quoted in the table are easily calculated from related sizes whose feetage is given. Doubling any one dimension of a piece of lumber doubles its volume, doubling two dimensions increases the volume fourfold, and doubling three dimensions increases the volume eightfold. Thus a 2x6, 6 feet long contains 6 board feet; a 2x6, 12 feet long, 12 board feet; a 2x12, 12 feet long, 24 board feet; and a 4x12, 12 feet long, 48 board feet. Conversely, since a 4x10, 12 feet long, contains 40 board feet, a 2x10 of the same length contains 20 board feet, a 1x10, 12 feet long, 10 board feet; a 1x5, 12 feet long, 5 board feet; and a 1x5, 6 feet long, 2½ board feet.

Log Rules.—Logs are usually bought and sold upon the basis of measurements which more or less accurately indicate the amount of lumber they will yield when sawed. A large number of these log rules or scales are in use in various sections of the country, but the most widely known rules are the Doyle rule and the Scribner rule. Neither of these rules is scientifically exact, but loggers and lumbermen are generally sufficiently well informed upon the relationship between the amount of lumber indicated in particular kinds of logs in a

TABLE OF BOARD MEASURE

Size in Inches	Length in Feet									
	6	8	10	12	14	16	18	20	22	24
1×4	2	2⅔	3⅓	4	4⅔	5⅓	6	6⅔	7⅓	8
1×6	3	4	5	6	7	8	9	10	11	12
1×8	4	5⅓	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16
1×10	5	6⅔	8⅓	10	11⅔	13⅓	15	16⅔	18⅓	20
1×12	6	8	10	12	14	16	18	20	22	24
1×14	7	9⅓	11⅔	14	16⅓	18⅔	21	23⅓	25⅔	28
1×16	8	10⅔	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
2×4	4	5⅓	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16
2×6	6	8	10	12	14	16	18	20	22	24
2×8	8	10⅔	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
2×10	10	13⅓	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40
2×12	12	16	20	24	28	32	36	40	44	48
2×14	14	18⅔	23⅓	28	32⅔	37⅓	42	46⅔	51⅓	56
2×16	16	21⅓	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64
3×6	9	12	15	18	21	24	27	30	33	36
3×8	12	16	20	24	28	32	36	40	44	48
3×10	15	20	25	30	35	40	45	50	55	60
3×12	18	24	30	36	42	48	54	60	66	72
3×14	21	28	35	42	49	56	63	70	77	84
3×16	24	32	40	48	56	64	72	80	88	96
4×4	8	10⅔	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
4×6	12	16	20	24	28	32	36	40	44	48
4×8	16	21⅓	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64
4×10	20	26⅔	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80
4×12	24	32	40	48	56	64	72	80	88	96
4×14	28	37⅓	46⅔	56	65⅓	74⅔	84	93⅓	102⅔	112
4×16	32	42⅔	53⅓	64	74⅔	85⅓	96	106⅔	117⅓	128
6×6	18	24	30	36	42	48	54	60	66	72
6×8	24	32	40	48	56	64	72	80	88	96
6×10	30	40	50	60	70	80	90	100	110	120
6×12	36	48	60	72	84	96	108	120	132	144
6×14	42	56	70	84	98	112	126	140	154	168
6×16	48	64	80	96	112	128	144	160	176	192
8×8	32	42⅔	53⅓	64	74⅔	85⅓	96	106⅔	117⅓	128
8×10	40	53⅓	66⅔	80	93⅓	106⅔	120	133⅓	146⅔	160
8×12	48	64	80	96	112	128	144	160	176	192
8×14	56	74⅔	93⅓	112	130⅔	149⅓	168	186⅔	205⅓	224
8×16	64	85⅓	106⅔	128	148⅔	170⅔	192	213⅓	234⅔	256
10×10	50	66⅔	83⅓	100	116⅔	133⅓	150	166⅔	183⅓	200
10×12	60	80	100	120	140	160	180	200	220	240
10×14	70	93⅓	116⅔	140	163⅓	186⅔	210	233⅓	256⅔	280
10×16	80	106⅔	133⅓	160	186⅔	213⅓	240	266⅔	293⅓	320
12×12	72	96	120	144	168	192	216	240	264	288
12×14	84	112	140	168	196	224	252	280	308	336
12×16	96	128	160	192	224	256	288	320	352	384
14×14	98	130⅔	163⅓	196	228⅔	261⅓	294	326⅔	359⅓	392
14×16	112	149⅓	186⅔	224	261⅓	298⅔	336	373⅓	410⅔	448

SCRIBNER LOG RULE

(Decimal "C.")*

Diameter, Inches	Length in Feet					
	6	8	10	12	14	16
6	0.5	0.5	1	1	1	2
7	0.5	1	1	2	2	3
8	1	1	2	2	2	3
9	1	2	3	3	3	4
10	2	3	3	3	4	6
11	2	3	4	4	5	7
12	3	4	5	6	7	8
13	4	5	6	7	8	10
14	4	6	7	9	10	11
15	5	7	9	11	12	14
16	6	8	10	12	14	16
17	7	9	12	14	16	18
18	8	11	13	16	19	21
19	9	12	15	18	21	24
20	11	14	17	21	24	28
21	12	15	19	23	27	30
22	13	17	21	25	29	33
23	14	19	23	28	33	38
24	15	21	25	30	35	40
25	17	23	29	34	40	46
26	19	25	31	37	44	50
27	21	27	34	41	48	55
28	22	29	36	44	51	58
29	23	31	38	46	53	61
30	25	33	41	49	57	66
31	27	36	44	53	62	71
32	28	37	46	55	64	74
33	29	39	49	59	69	78
34	30	40	50	60	70	80
35	33	44	55	66	77	88
36	35	46	58	69	81	92
37	39	51	64	77	90	103
38	40	54	67	80	93	107
39	42	56	70	84	98	112
40	45	60	75	90	105	120
41	48	64	79	95	111	127
42	50	67	84	101	117	134
43	52	70	87	105	122	140
44	56	74	93	111	129	148
45	57	76	95	114	133	152
46	59	79	99	119	139	159
47	62	83	104	124	145	166
48	65	86	108	130	151	173

* The total scale is obtained by multiplying the figures in this table by 10. Thus, the contents of a 6-inch 8-foot log are given as 0.5, so the total scale is 5 board feet. A 30-inch 16-foot log is given as 66, or a total scale of 660 board feet.

given locality by the prevailing scale and the quantity actually produced when the logs go through the mill, so that deficiencies in the scale or the timber are allowed for in calculations.

In scaling logs, the diameter is usually measured in inches at the small end inside the bark, and the length in feet. A handy method of carrying the Doyle rule in mind is by the formula $\left(\frac{D-4}{4}\right)^2 l$ in which D is the diameter of the log in inches and l the length in feet. For example, if the log is 24 inches in diameter and 16 feet long the calculation is $\left(\frac{24-4}{4}\right)^2$ $\times 16 = 25 \times 16 = 400$ and the log scales 400 feet Doyle rule. The quantity of lumber actually sawed from such a log might be as much as 25 per cent in excess of the Doyle scale, depending upon kind and quality of timber, gauge of saw used, etc.

One of the most widely used log rules is the "Decimal C" Scribner rule, in which fractions are disregarded and the measurement in each case given to the nearest multiple of 10 feet in contents. This is the rule used by the United States Forest Service in measuring timber sold from the National Forests (see Table on page 63), for logs up to 48 inches in diameter 6 to 16 feet long.

CHAPTER VI

SHIPPING WEIGHTS

The lumber manufacturer usually makes quotations upon the basis of delivery of the lumber to any point desired. To do this, it is necessary for the shipper to know the weight of the product in order to figure freight charges and add them to the f. o. b. mill price. For this reason, the grading rules of practically all lumber manufacturers' associations carry tables of estimated weights of lumber when dried to what is called "shipping condition." These weights are, of course, somewhat arbitrary; but they are based upon long experience, and are fair approximations of the weights of the commercial products which they represent. So far as they vary from actual weights, the estimated weights are likely to be a little higher than the exact weights. On the other hand, there is so much difference in the weight of wood depending upon the amount of seasoning, that not infrequently lumber is shipped when it is decidedly heavier than the estimated weights.

Softwoods.—Estimated shipping weights of typical products of the principal softwoods in air-dry condition are indicated in Table 11.

Hardwoods.—The average shipping weight for the common hardwoods as determined by the National Hardwood Lumber Association are indicated in Table 12.

TABLE 11

SHIPPING WEIGHTS OF SOFTWOODS

(Air-dried Except Where Otherwise Stated—Weights Indicated in Pounds per 1,000 Feet, Board Measure)

	Timbers, Rough	2″ Dimension		1″ Boards		$\frac{13}{16}$″ Flooring	$\frac{13}{16}$″ Drop Siding	$\frac{3}{4}$″ Drop Siding	$\frac{5}{8}$″ Ceiling	4′ Lath
		Rough	S-1-S-1-E	Rough	S-1-S or S-2-S					
White Pine and Hemlock	3,000	2,500	2,200	2,400	2,000	1,800	1,800	....	1,500	500
Longleaf Pine (Southern Pine Ass'n)	4,500	....	2,700	....	2,700	2,200	....	1,900	1,500	550
Shortleaf Pine (Southern Pine Ass'n)	4,200	....	2,500	....	2,500	2,000	....	1,800	1,400	500
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	....	....	3,500	....	2,800	2,250	....	2,300	....	550
North Carolina Pine (Kilndried)	....	3,500	....	3,100	2,500	2,250	2,000	....	1,700	
Cypress	....	3,200	2,600	3,000	2,400	2,200	2,200	....	1,600	500
Douglas Fir	3,300	3,300	2,600	3,300	2,500	2,000	....	2,000	1,400	500
Western Spruce	....	....	....	....	2,500	2,000	....	....	1,300	500
Western Hemlock	....	....	....	....	2,500	2,000	....	2,000		
Idaho White Pine	....	2,500	2,200	2,400	2,000	....	....	1,800	....	500
Western Pine, Larch, Fir	....	2,500	2,200	2,400	2,000	2,000	2,200	1,800	1,300	500
Sugar Pine	....	2,650	2,300	2,500	2,200	....	....	....	....	450
Redwood	....	2,600	2,200	2,400	2,000					

TABLE 12

Official Standard Weights of Hardwood Lumber

Kinds of Wood	Thickness	Condition	Lbs. per 1,000 Ft. Dry
Ash	1″ and thicker	rough	3,500
Basswood	1″ and thicker	rough	2,600
Beech	1″ and thicker	rough	4,000
Birch	1″ and thicker	rough	4,000
Buckeye	1″ and thicker	rough	2,600
Butternut	1″ and thicker	rough	2,800
Cherry	1″ and thicker	rough	4,000
Chestnut	1″ and thicker	rough	2,800
Cottonwood	1″ and thicker	rough	2,800
Cottonwood	½″ bevel siding		850
Cottonwood	⅜″	S2S	1,000
Cottonwood	½″	S2S	1,200
Cottonwood	⅝″	S2S	1,500
Elm (soft)	1″ and thicker	rough	3,200
Elm (rock)	1″ and thicker	rough	3,800
Gum	1″ and thicker	rough, red	3,300
Gum	1″ and thicker	rough, sap	3,100
Gum	½″ bevel siding	S1S	900
Gum	13/16″ drop siding	S2S	2,200
Gum	13/16″ flooring	S2S	2,200
Gum	⅜″ ceiling	S2S	850
Gum	½″ ceiling	S2S	1,300
Gum	¾″ ceiling	S2S	2,000
Gum	⅝″ ceiling	S2S	1,600
Gum	1″	S2S 13/16″ red	2,500
Gum	1″	S2S 13/16″ sap	2,350
Hickory	1″	rough	5,000
Hickory	Axles and reaches	rough, dry	4,500
Hickory		green	6,000
Hickory	Rim strips	rough	5,000
Maple (soft)	1″ and thicker	rough	3,000
Maple (hard)	1″ and thicker	rough	4,000
Oak	1″ and thicker	rough	3,900
Oak	⅜″ thick	rough	2,000
Oak	½″ thick	rough	2,200
Oak	⅝″ thick	rough	2,700
Oak	¾″ thick	rough	3,200
Oak chair and furniture stock, 1″ and thicker			4,200
Oak square	1″×1″ and larger		4,200
Oak wagon stock and felloes		dry	4,500
Oak wagon stock and felloes		green	6,000
Oak plow handle strips		dry	4,250
Poplar	1″ and thicker	rough	2,800
Poplar	⅝″	rough	1,600
Poplar	¾″	rough	2,100
Poplar	½″ bevel siding	S2S	850
Poplar	Drop siding	S2S	2,000
Poplar	⅜″ ceiling	S2S	800
Poplar	½″ ceiling and partition	S2S	1,200
Poplar	⅝″ ceiling and partition	S2S	1,500
Poplar	¾″ ceiling and partition	S2S	1,750
Poplar	13/16″ ceiling and partition	S2S	2,000
Poplar	1″	S2S, to 13/16″	2,200
Sycamore	1″ and thicker	rough	3,200
Walnut	1″ and thicker	rough	4,000

FLOORING

The weights of kiln dried flooring used by the oak and maple manufacturers are:

Oak Flooring, ⅜"x1½", 900 lbs.; ⅜"x2", 1,000 lbs.; 13/16"x1½", 1,800 lbs.; 13/16"x2", 1,900 lbs.; 13/16"x2¼", 2,000 lbs.

Maple, Beech, and Birch Flooring, ⅜"x1½" or 2¼", 1,000 lbs.; 13/16"x1½" or 2¼", 2,000 lbs.

Logs.—The shipping weights of hardwood logs adopted by the National Hardwood Lumber Association are as follows:

Official Standard Weight of Hardwood Logs

(Pounds per foot, log scale)

Ash	10.00	Cottonwood	11.50
Cypress	9.00	Elm	10.00
Hickory	13.00	Gum	11.00
Poplar	7.50	Oak	11.00

CHAPTER VII

STRUCTURAL TIMBERS

Timbers are usually sawed from the heart of the log. It pays the lumber manufacturer better to cut the clear, outside portions of the log into higher classes of material than it does to cut them into timbers which bring a lower market price. For this reason, timbers may contain many or all of the defects common to the species from which they are cut. Since, however, timbers are large pieces of wood which are used as a whole, some small defects do not greatly reduce the strength, and larger defects of certain kinds may not be serious unless located at the points where the greatest strength is required.

The most serious defects in structural timbers are rot, knots, checks, shake, and cross-grain. Sometimes a beam or timber may be so placed that these defects will not seriously interfere with strength, whereas in a reverse position, they would lessen the strength of the piece. For example, knots near the center line or ends have practically no effect upon the strength of a beam.

The rate of growth is often thought to have much effect upon the strength of large timbers; but the density of wood is a much better criterion of its strength than is the rate of growth. The seasoning of small sticks greatly increases their strength, but it is not safe to assume that large timbers when seasoned are much stronger than when green. This is because checks which develop in seasoning are likely to offset the increase in strength due to the drying of the wood. For this reason, engineers do not ordinarily consider it advisable to figure upon a greater load for seasoned timbers than would be safe for timbers of the same size when green.

The Forest Service experiments in seasoning large timbers lead to these conclusions:

(1) In general, timber 8 by 16 inches in cross-section must season through two entire summers before it reaches a thoroughly air-dry condition.

(2) The weight of thoroughly air-seasoned timbers will vary appreciably during the year, due to the alternate evaporation and absorption of moisture. This change in moisture content is accompanied by a corresponding shrinking and swelling which tends to increase the size and number of checks formed through the seasoning process. These hygroscopic changes, however, do not seem to affect the interior of the timbers.

(3) If seasoning is started in the hot summer months, the loss of moisture is at first very rapid, even though the timber is protected from the sun and wind. The rapid loss in weight is associated with a marked shrinkage in the outer portion of the timber, which invariably induces checking. The loss in weight in a stringer 8 by 16 inches in cross-section and 16 feet long, in three months, varies from 40 to 60 pounds, the loss being proportional in a general way to the amount of sapwood the timber contains. Checking is less serious, however, when the timbers contain a considerable amount of sapwood than when they are practically all heartwood.

(4) The best results are obtained when the air-seasoning is started in the late fall or early winter months. At this time of the year the air is usually moist enough to prevent rapid drying on the surface, and, in consequence, serious checking.

(5) The absence of shrinkage in redwood timbers is very noticeable, although redwood contains a large amount of moisture when cut. On account of its low-shrinkage factor, it can be seasoned without serious checking.

ASSOCIATION RULES FOR STRUCTURAL TIMBERS

The definitions and specifications for select structural timbers adopted by the Southern Pine Association are:

DEFINITION FOR SOUTHERN YELLOW PINE

(*Adopted and Copyrighted by the American Society for Testing Materials, August,* 1915.)

Southern Yellow Pine: This term includes the species of yellow pine growing in the Southern States from Virginia to Texas, that is, the pines hitherto known as longleaf pine (*Pinus palustris*), shortleaf pine (*Pinus echinata*), loblolly pine (*Pinus taeda*), Cuban pine (*Pinus heterophylla*), and pond pine (*Pinus serotina*).

Under this heading two classes of timber are designated: (*a*) dense Southern yellow pine and (*b*) sound Southern yellow pine. It is under-

stood that these two terms are descriptive of quality rather than of botanical species.

(*a*) Dense Southern yellow pine shall show on either end an average of at least six annual rings per inch and at least one-third summer wood, or else the greater number of the rings shall show at least one-third summer wood, all as measured over the third, fourth and fifth inches of a radial line from the pith. Wide-ringed material excluded by this rule will be acceptable, provided that the amount of summer wood as above measured shall be at least one-half.

The contrast in color between summer wood and spring wood shall be sharp and the summer wood shall be dark in color, except in pieces having considerably above the minimum requirement for summer wood.

In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over 3 in. on an approximate radial line beginning at the edge nearest the pith in timbers over 3 in. in thickness and on the second inch (on the piece) nearest to the pith in timbers 3 in. or less in thickness.

In dimension material containing the pith but not a 5-in. radial line, which is less than 2 by 8 in. in section or less than 8 in. in width, that does not show over 16 square inches on the cross-section, the inspection shall apply to the second inch from the pith. In larger material that does not show a 5-in. radial line the inspection shall apply to the three inches farthest from the pith.

The radial line chosen shall be representative. In cases of disagreement between purchaser and seller the average summerwood and number of rings shall be the average of the two radial lines chosen.

(*b*) Sound Southern yellow pine shall include pieces of Southern pine without any ring or summer wood requirement.

GENERAL TIMBER SPECIFICATIONS

All timber except No. 1 Common must be free from defects such as injurious ring or round shakes, and through shakes that extend to the surface; unsound and loose knots, and knots in groups that will materially impair the strength. Seasoning checks and discolored sap shall not be considered defects in any grade.

Knots

Knots shall be classified as round and spike in form, and for quality as sound, encased, loose and unsound.

A round knot is oval or circular in form.

A spike knot is one sawn in a lengthwise direction.

A sound knot is one solid across its face, is as hard as the wood which surrounds it, may be either red or black, and fixed by growth or position so that it will retain its place in the piece.

An incased knot is one whose growth rings are not interwoven and homogeneous with the growth rings of the piece it is in. The encasement may be partial or complete; if intergrown partially or so fixed by growth or position that it will retain its place in the piece, it shall be considered a sound knot; if completely intergrown on one face, it is a watertight knot.

A loose knot is one not held firmly in place by growth or position.

An unsound knot is one not as hard as the wood it is in.

Wane

Wane is bark or the lack of wood from any cause, on edges of timbers.

Shakes

Shakes are splits or checks in timbers which usually cause a separation of the wood between annual rings.

A ring shake is an opening between the annual rings.

A through shake is one which extends between two faces of a timber.

Shakes not hereinbefore described, unless known to have extensive penetration, shall not be considered a defect under this classification.

Sizes

All rough timber, except No. 1 Common, must be full size when green. One-quarter inch shall be allowed for each side surfaced.

Lengths

Standard lengths are multiples of two feet, eight to twenty feet, inclusive; extra lengths are multiples of two feet, twenty-two feet and longer. When lineal average is specified, standard of lengths shall be multiples of one foot.

GRADES OF TIMBERS

Heart Timbers

All timber specifications, except ''Merchantable'' and ''Select Structural Timbers'' specifying heart requirements shall be considered as a special contract, and shall specify whether the heart requirements refer to surface or girth measurements in each piece.

No. 1 Common Timbers

May be either Dense or Sound Pine.

Unless otherwise specified, this grade will admit any amount of sapwood.

Common timbers, rough, 4x4 and larger may be ¼ in. scant in either or both of its dimension, shall be well manufactured and may have 1½ in. wane on one corner one-third the length of the piece, or its equivalent on two or more corners, the wane measured on its face.

Timbers 10x10 in. size may have 2-in. wane as above; the larger sizes may have wane as above in proportion to sizes.

Common timbers may contain sound knots and pith knots, provided that the diameter of any one knot shall not exceed 2 in. in 4x4 to 6x6; 2½ in. in 6x8 to 8x10; 3 in. in 10x10 to 10x12; 3½ in. in 12x12 to 12x14; 4 in. in 14x14 to 14x16; 4½ in. in 16x16 to 16x18. In sizes not mentioned the diameter of knots admissible will increase or decrease in proportion to the size of the timbers on same basis as above specified.

In determining the size of knots, mean or average diameter shall be taken, or the equivalent of the above in grouped knots at any one point. Shakes one-sixth the length of the piece, small unsound knots 1½ in. or less in diameter, a limited number of pin-worm holes, well scattered, sap stain, and seasoning checks are admissible.

Square-Edge and Sound Timbers

May be either dense or sound pine.

Unless otherwise specified, this grade will admit any amount of sap-wood.

Square edge and sound timbers shall be well manufactured and shall be free from defects such as injurious ring or round shakes and through shakes that extend to the surface, unsound and loose knots in groups that will materially impair the strength, and shall be free from wane. Seasoning checks and sap stain shall not be considered defects.

Merchantable Timbers

May be either dense or sound pine.

All merchantable timbers shall be well manufactured and shall be free from defects such as injurious ring and round shakes and through shakes that extend to the surface, unsound and loose knots, and knots in groups that will materially impair the strength. Seasoning checks and sap stain shall not be considered defects.

Sizes under 9 in. on the largest dimension, shall show two-thirds or more heart surface on one of the wide faces; sizes 9 in. and over on the largest dimension shall show two-thirds or more heart on both of the wide faces. When sticks are square the face showing the most heart shall govern the inspection on sizes under 9 in., and the two faces showing the most heart shall govern the inspection when 9 in. and over. Heart showing the full length, even if not two-thirds of the area as above, shall meet the requirements of this quality.

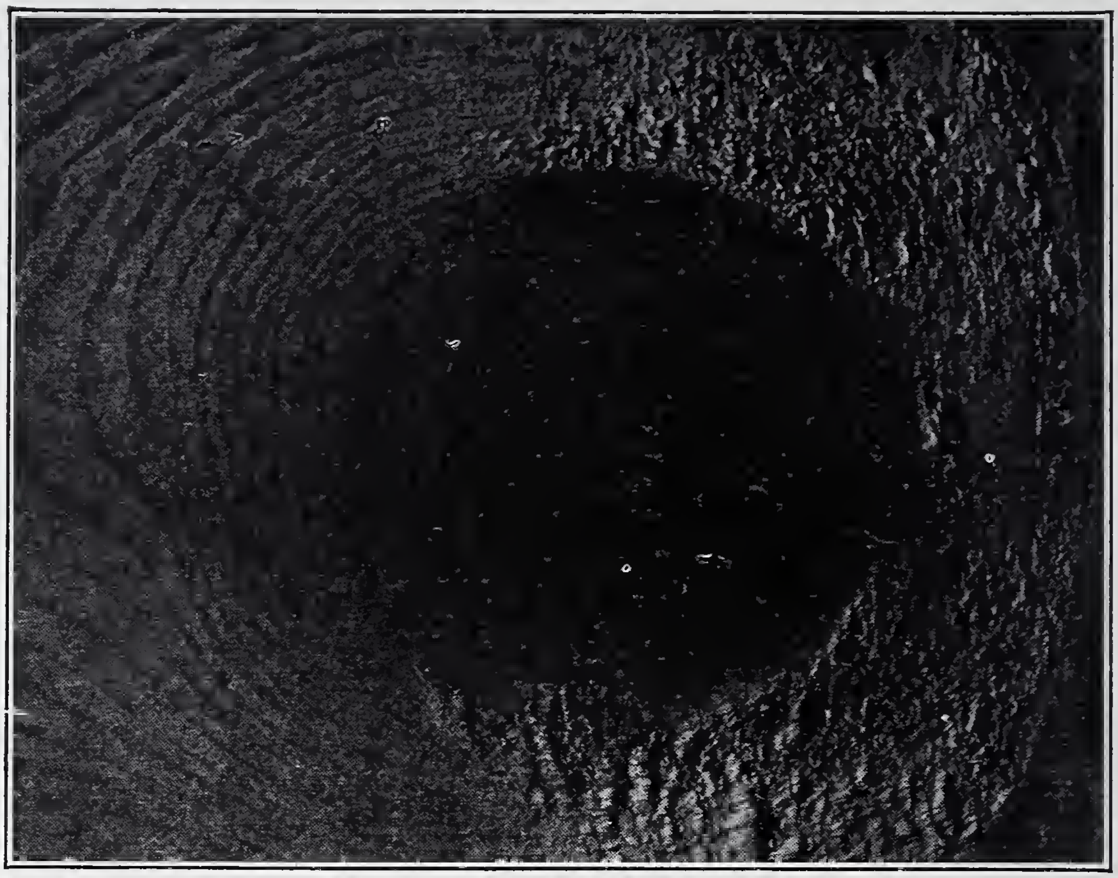


Fig. 18.—Standard Knot.

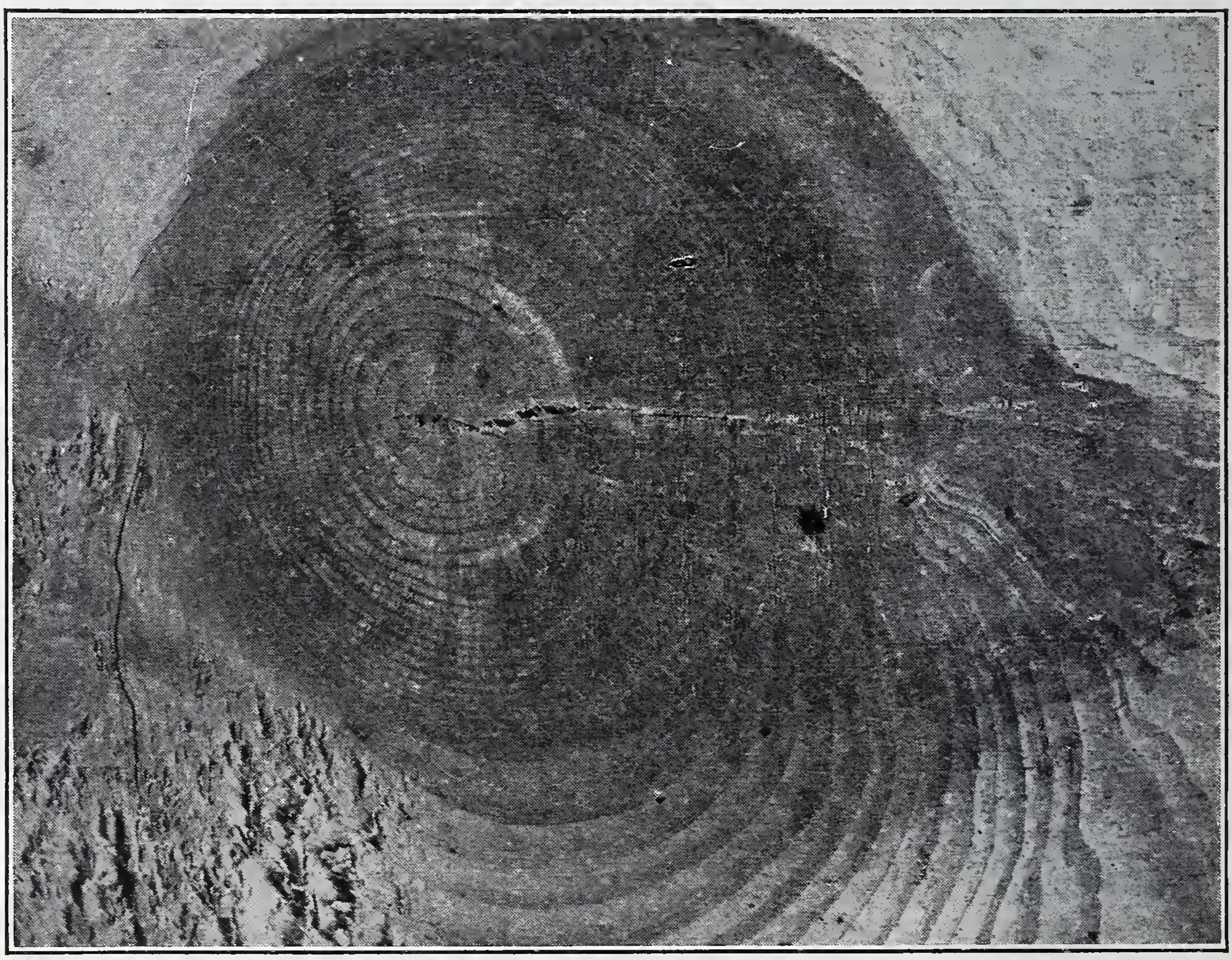


Fig. 19.—Large Knot.

STANDARD KNOTS

Wane not exceeding one-eighth of the dimension of the face and one-quarter of the length of the piece on one corner, or the equivalent on two or more corners on not to exceed 10 per cent of the pieces, shall be admitted.

SELECT STRUCTURAL YELLOW PINE

(*A rule incorporating suggestions by the Forest Products Laboratory.*)

Requirements for Density and Rate of Growth

1. Shall contain only sound wood and be well manufactured.

2. Shall conform to the definition of dense southern pine as adopted by the American Society for Testing Materials, August 21, 1915.

Unless otherwise specified, select structural material shall show 85 per cent of heart, girth measurement, measured anywhere in the length of the piece. Any greater or less requirement as to heart shall be expressed in terms of per cent of girth measurement. Sap stain is not a defect in this grade.

For the purpose of determining whether any given piece meets the requirements for density and rate of growth, the following rule, suggested by the Forest Products Laboratory, shall be applied. It will be sufficient if either end passes the inspection.

(1) Pith present or accurately located.

(A) Radial line of 5 in. present.

(*a*) Apply inspection over third, fourth and fifth inches.

(B) Radial line of 5 in. not present.

Apply inspection to the second inch on 2x3, 2x4, 2x6, 3x3, 3x4, 4x4, or any other dimension material that has less than 16 sq. in. on the cross-section

(*b*) In the larger material apply inspection to the three inches farthest from the pith.

(2) Pith not present or cannot be accurately located.

(A) Material over 3 in. thick apply inspection to three inches nearest the pith.

(B) Dimension material 3 in. or less in thickness apply inspection to second inch of the piece nearest the pith.

(3) The radial line chosen shall show a representative number of annual rings of growth and per cent of summerwood.

Restrictions on Knots in Beams

3. Shall not have in Volume 1 sound knots greater in diameter than one-fourth the width of the face on which they appear—maximum knot 1½ in. Shall not have in Volume 2 sound knots greater in diameter than one-half the width of the face on which they appear—maximum knot 3 in.

The aggregate diameter of all knots within the center half of the length of any face shall not exceed the width of that face.

The diameter of a knot on the narrow or horizontal face of a beam is to be taken as its projection on a line perpendicular to the edge of the timber. On the wide or vertical face, the smallest dimension of a knot is to be taken as its diameter.

Restrictions on Knots in Columns

4. Shall not have sound knots greater in diameter than one-third the least width of the column—maximum knots 4 in.

Restrictions on Shakes and Checks in Beams

5. Round or ring shakes shall not occupy, at either end of a timber, more than one-fourth the width of green material, nor more than one-third the width of seasoned material.

Any combination of checks and shakes which would reduce the strength to a greater extent than the allowable round shakes will not be permitted. Shakes shall not show on the faces of either green or seasoned timber.

Restrictions on Cross Grain in Beams

6. Shall not have diagonal grain with slope greater than one in twenty in Volume 1.

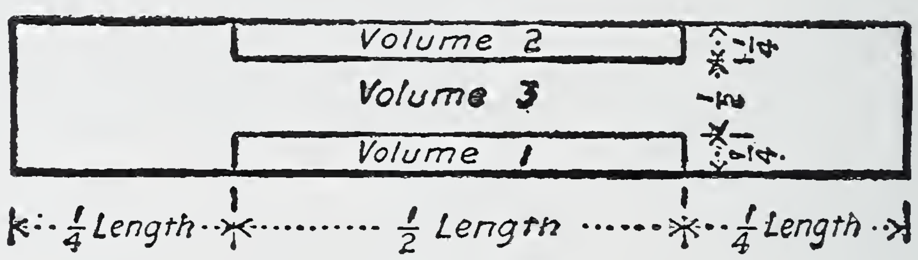


Fig. 20.

DENSE DOUGLAS FIR

The following method of determining the quality of Douglas fir desirable in structural timbers is recommended by the Forest Products Laboratory as accepting the greatest number of timbers with which the highest recommended working stresses can be used. Dense material may be obtained in any grade and is desirable when strength, hardness, or durability are factors.

Dense Douglas fir shall show on one end or the other an average of at least six annual rings per inch and at least one-third summerwood measured over 3 inches on a line located as described hereinafter. Coarse grained material, excluded

by this rule, shall be acceptable provided that the amount of summerwood measured as described shall be at least one-half. Material in which the proportion of summerwood is not clearly discernible shall not be accepted.

Any timber whose least dimension is less than 5 inches shall not show the pith (heart) on the inspection end; pieces whose least dimension is 5 inches or more may contain the pith.

Pith Present.—When the least dimension is 5 inches or more, the pith being present, the line over which the rate of growth and per cent of summerwood measurements shall be made shall run from the pith to the corner farthest from the pith. To find the beginning of the 3-inch line measure a distance of one-half the least dimension of the piece, less 2 inches, from the pith. The distance may be expressed as follows: $a = \frac{1}{2}d - 2$, where a=distance in inches from pith to beginning of the 3-inch line; d=least dimension of piece in inches.

When the rings are very irregular it may be necessary to shift the line somewhat around the piece to get a fair average for inspection, but the distance from the pith to the beginning of the 3-inch line must not be changed.

Pith Not Present.—For all pieces where the pith is not present the center of the 3-inch line shall be at the center of the end of the piece, and the direction of the 3-inch line shall be at a right angle to the annual rings.

If a radial line of 3 inches cannot be obtained, the measurement shall be made over the entire radial line that is available.

Structural Grades.—The following rules contain minimum requirements and maximum defects, all of which may be present at one time; when a particular timber is slightly below the provisions of the grade in some of these properties and somewhat above in others the relative effect should be considered in accepting or rejecting it.

General Requirements.—Sizes—S-1-S-1-E or S-4-S, 4″x4″ and larger, ½″ off each way.

Manufacture.—Structural grades shall be of sound wood and well manufactured, with square edges; occasional slight variation in sawing will be allowed.

Knots.—Structural timbers shall be free from rotten or unsound knots or knots in clusters. Knots limited in size and position as hereinafter provided will be permitted if so fixed

by growth or position that they will retain their place in the piece at the time of manufacture. The limiting size of a knot in a post shall be applied to the mean or average diameter of the knot; the limiting size of a knot on the narrow face of a beam shall be applied to its projection on a line perpendicular to the edge of the timber; on the wide face it shall be applied to its smallest diameter. For the limitation of knots in beams in size and location a beam shall be considered as divided into three volumes. (See diagram, page 76).

Shakes and Checks.—Round or ring shakes shall not occupy more than one-fourth the least dimension on either end of a timber; a round or ring shake shall be measured on its vertical projection. Any combination of checks and shakes which would reduce the strength to a greater extent than the allowable round shakes is not permitted. Shakes must not show on any face of a timber.

Angle of Grain.—Beams shall not have diagonal or spiral grain in volumes 1 and 2 with slope greater than 1 in 20; in posts the angle shall not be greater than 1 in 15.

Bills of Material.—Posts and beams have different restrictions as to knots and angle of grain and must be listed accordingly in bills of material.

No. 1 Structural Douglas Fir

No. 1 structural timbers shall be of dense Douglas fir and shall meet the general requirements for structural grades.

This grade may have tight pitch pockets not over 6 inches in length and wane not to exceed 1 inch on one corner nor one-sixth the length of the piece.

Loose knots larger than ½ inch shall not be permitted.

Posts shall not have knots larger than one-fourth the least dimension of the post, nor larger than 3 inches.

Beams shall not have knots in volumes 1 and 2 larger than one-fourth the width of the face of the beam in which they occur, up to and including 6 inches, nor larger than 1½ inches in a face over 6 inches. Knots within the center half of the length of a beam shall not exceed in the aggregate the width of the surface of the beam in which they occur. Knots in volume

3, on either end of the center half of a beam, shall not be larger than one-fourth the width of the surface in which they occur.

No. 2 Structural Douglas Fir

No. 2 structural timbers shall meet the general requirements for structural grades and shall include timbers not passing the No. 1 grade because of having: (*a*) less density than is required, or (*b*) greater defects than are permitted.

This grade may have pitch pockets not longer than 12 inches and may have 2-inch wane on one corner or the equivalent on two or more corners of 10″x10″ timbers, with wane in proportion on smaller or larger sizes.

Posts may have knots as follows:

(*a*) If of dense Douglas fir, not larger than one-third the least dimension of the post, nor larger than 4 inches.

(*b*) If not of dense Douglas fir, not larger than one-fourth the least dimension of the post, nor larger than 3 inches.

Beams shall not have knots in volumes 1 and 2 larger than as follows:

(*a*) If of dense Douglas fir, not larger than one-third the width of the face of the beam in which they occur, up to and including 9 inches, nor larger than 3 inches in a face over 9 inches.

(*b*) If not of dense Douglas fir, not larger than one-fourth the width of the face of the beam in which they occur, up to and including 6 inches, nor larger than 1½ inches in a face over 6 inches.

Knots within the center half of the length of a beam shall not exceed in the aggregate twice the width of the surface of the beam in which they occur. Knots in volume 3, on either end of the center half of a beam, shall not be larger than one-third the width of the surface in which they occur.

Loose knots larger than one-half the size of the knots allowed above shall not be permitted; beams shall not have loose knots in volume 3 larger than 1½ inches.

Working Stresses for Douglas Fir

The following working stresses are recommended by the Forest Products Laboratory, for structural Douglas fir timbers:

	No. 1 Structural	No. 2 Structural
Bending:		
Extreme fiber stress (2)		
Wet Location	1,100	900
Outside Location	1,400	1,100
Dry Location	1,600	1,300
Maximum Shear:		
Horizontal		
All Locations	100 (3)	90 (3)
Compression:		
Parallel to Grain (4)		
Wet Location	950	850
Outside Location	1,200	1,000
Dry Location	1,300	1,100
Perpendicular to Grain		
Wet Location	225	200
Outside Location	250	225
Dry Location	375	325
Elasticity:		
Average Modulus		
All Locations	1,600,000	1,400,000

(1) In this grade pieces of exceptionally low density should not be placed in positions where they will receive long continued loads producing maximum allowable stresses.

(2) Where timbers are in direct tension the same values as for extreme fiber stress in bending may be used. Wood has greater resistance to tension than to any other kind of stress, and it has been found difficult to break it in a true tensile test.

(3) These values are based on present inadequate information concerning the effect of seasoning on shearing values in Douglas fir, further investigation in regard to which is now under way.

(4) A short column is more likely to fail at the end than at any other point and the variations in moisture are greater there; for these reasons the same stresses would be used in end bearing as for short columns. For "long columns," i.e. compression members with an unsupported length greater than about ten times their least diameter, these values should be reduced according to a column formula. Such formulae are given and discussed in the various text books on mechanics, and in treatises on structural design.

(5) Timber constantly yields under long-continued loading,

and will fail finally at a load little more than half that required to break it when applied rapidly in a test; for application to a beam which is to be subjected to long-continued loading, therefore, moduli of elasticity one-half those given above should be used.

Suggestions for Use of Grading Rules*

When timbers in direct tension are designed for full working stresses, defects throughout the entire stick should be limited as in volumes 1 and 2 of beams.

When beams are of two spans length, volumes 1 and 2 should be considered as extending between points located one-eighth the length of the beam from each end.

When posts are designed for less than full working stresses, the angle of grain may be increased proportionately to the reduction in stress; that is, with a working stress one-half the full working stress allowed the angle of the grain may be 1 in 7½.

When resistance to decay is a factor, sapwood should not be permitted.

Density may be specified independently of structural properties; density should be required where resistance to decay or abrasion are factors.

For sills, caps, plates, and other members where bending stresses are low compared with compression across the grain, density should be required, but special limitations as to sound knots and angle of grain are not necessary.

For posts, where large sizes are required for harmony with the balance of the construction and where resistance to decay is not an important factor, timbers without density requirements may be used.

For studding and wall construction, where the spacing of members is governed by requirements for nailing members or supports to wall covering, commercial grades without density requirement may be used.

For joists, where stiffness is a controlling factor rather than bending stresses or resistance to decay, density need not be

* These suggestions are not a part of the rules, but are merely suggestions for their use.

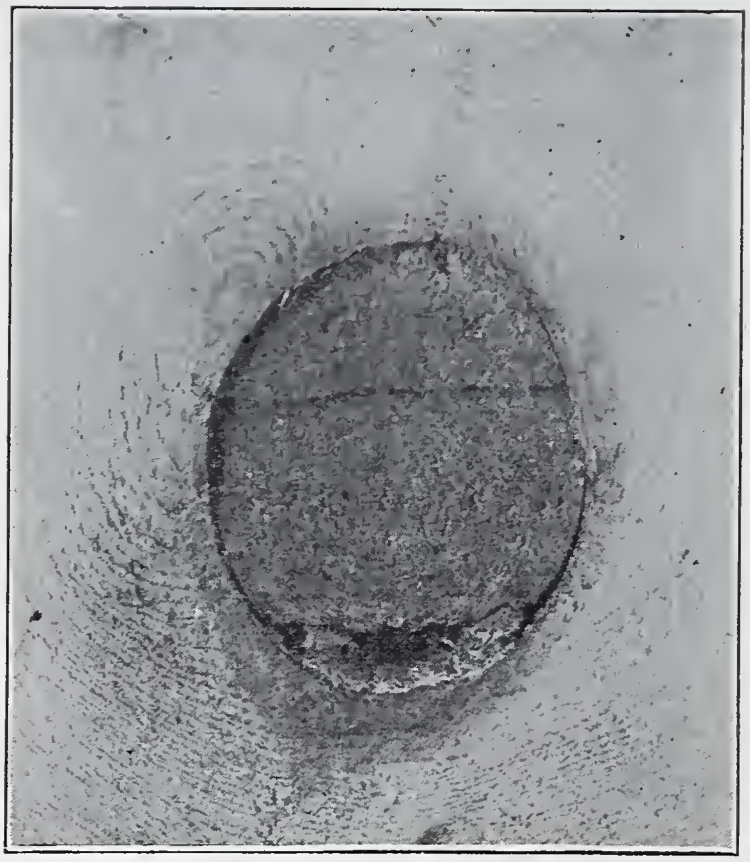


Fig. 21.—Loose Knot.

Fig. 22.—Encased Knot.

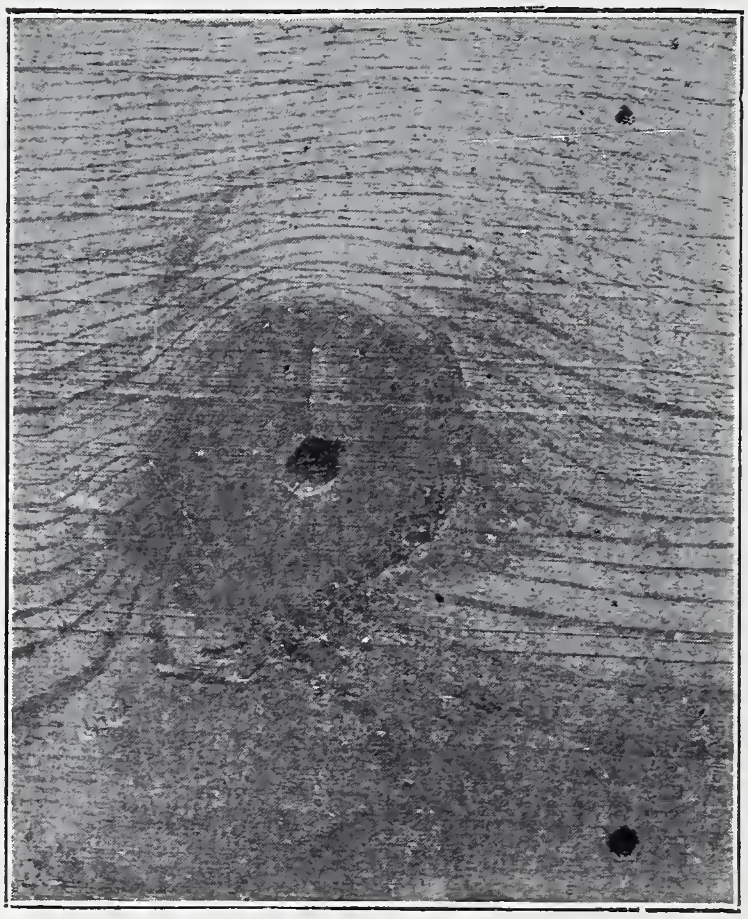


Fig. 23.—Pith Knot.

Fig. 24.—Rotten Knot.

STANDARD KNOTS

required, there being only slightly greater stiffness in dense material.

AMERICAN SOCIETY FOR TESTING MATERIALS

The American Society for Testing Materials has been working for years to establish commercial standards for all structural materials upon a scientific basis. The specifications which it has adopted for structural timber are as follows:

I. Definition of Structural Timber

By the term "Structural Timber" is understood all such products of wood in which the strength of the timber is the controlling element in their selection and use. The following is a list of products which are recommended for consideration as structural timbers:

Trestle Timbers.—Stringers, caps, posts, mud sills, bracing, bridge ties, guard rails.

Car Timbers.—Car framing, including upper framing; car sills.

Framing for Buildings.—Posts, mud sills, girders, framing, joists.

Ship Timbers.—Ship timbers, ship decking.

Cross-Arms for Poles.

II. Standard Defects

Measurements which refer to the diameter of knots or holes should be considered as referring to the mean or average diameter.

1. **Sound Knot.**—A sound knot is one which is solid across its face, and which is as hard as the wood surrounding it; it may be either red or black, and is so fixed by growth or position that it will retain its place in the piece.

2. **Loose Knot.**—A loose knot is one not firmly held in place by growth or position.

3. **Pith Knot.**—A pith knot is a sound knot with a pith hole not more than ¼ inch in diameter in the center.

4. **Encased Knot.**—An encased knot is one whose growth rings are not intergrown and homogeneous with the growth rings of the piece it is in. The encasement may be partial or complete; if intergrown partially or so fixed by growth or position that it will retain its place in the piece, it shall be considered a sound knot; if completely intergrown on one face, it is a watertight knot.

5. **Rotten Knot.**—A rotten knot is one not as hard as the wood it is in.

6. **Pin Knot.**—A pin knot is a sound knot not over ½ inch in diameter.

7. **Standard Knot.**—A standard knot is a sound knot not over 1½ inches in diameter.

8. **Large Knot.**—A large knot is a sound knot more than 1½ inches in diameter.

9. **Round Knot.**—A round knot is one which is oval or circular in form.

10. **Spike Knot.**—A spike knot is one sawn in a lengthwise direction; the mean or average width shall be considered in measuring these knots.

11. **Pitch Pockets.**—Pitch pockets are openings between the grain of the wood containing more or less pitch or bark. These shall be classified as "small," "standard," and "large" pitch pockets.

(a) **Small Pitch Pocket.**—A small pitch pocket is one not over ⅛ of an inch wide.

(b) **Standard Pitch Pocket.**—A standard pitch pocket is one not over ⅜ of an inch wide or 3 inches in length.

(c) **Large Pitch Pocket.**—A large pitch pocket is one over ⅜ of an inch wide or over 3 inches in length.

12. **Pitch Streak.**—A pitch streak is a well-defined accumulation of pitch at one point in the piece. When not sufficient to develop a well-defined streak, or where the fiber between grains—that is, the coarse-grained fiber, usually termed "springwood"—is not saturated with pitch, it shall not be considered a defect.

13. **Wane.**—Wane is bark, or the lack of wood from any cause, on edges of timbers.

14. **Shakes.**—Shakes are splits or checks in timbers which usually cause a separation of the wood between annual rings.

15. **Rot, Dote, and Red Heart.**—Any form of decay which may be evident either as a dark red discoloration not found in the sound wood, or the presence of white or red rotten spots, shall be considered as a defect.

16. **Ring Shake.**—An opening between the annual rings.

17. **Through Shake.**—A shake which extends between two faces of a timber.

III. Standard Names for Structural Timbers

1. **Southern Yellow Pine.**—This term includes the species of yellow pine growing in the Southern States from Virginia to Texas, that is, the pines hitherto known as long leaf pine (*Pinus palustris*), shortleaf pine (*Pinus echinata*), loblolly pine (*Pinus taeda*), Cuban pine (*Pinus heterophylla*) and pond pine (*Pinus serotina*).

2. **Douglas Fir.**—The term Douglas Fir is to cover the timber known likewise as yellow fir, red fir, Western fir, Washington fir, Oregon or Puget Sound fir or pine, northwest and west coast fir.

3. **Norway Pine,** to cover what is known also as red pine.

4. **Hemlock,** to cover southern or eastern hemlock—that is, hemlock from all states east of and including Minnesota.

5. **Western Hemlock,** to cover hemlock from the Pacific coast.

6. **Spruce,** to cover eastern spruce—that is, the spruce timber coming from points east of and including Minnesota.

7. **Western Spruce,** to cover the spruce timber from the Pacific coast.

8. **White Pine,** to cover the timber which has hitherto been known as white pine, from Maine, Michigan, Wisconsin and Minnesota.

9. **Idaho White Pine,** the variety of white pine from western Montana, northern Idaho, and eastern Washington.

10. **Western Pine,** to cover the timber sold as white pine coming from Arizona, California, New Mexico, Colorado, Oregon, and Washington. This timber is sometimes known as western yellow pine, or Ponderosa pine, or California white pine, or western white pine.

11. **Western Larch,** to cover the species of larch or tamarack from the Rocky mountain and Pacific coast regions.

12. **Tamarack,** to cover the timber known as tamarack or eastern tamarack from states east of and including Minnesota.

13. **Redwood,** to include the California wood usually known by that name.

FOREST SERVICE TESTS

The Forest Products Laboratory has made a long series of tests upon structural timbers of various kinds, which lead to these conclusions:

(1) The mechanical properties of timber beams are dependent upon: a, The quality of the wood irrespective of defects; b, the character and location of defects.

(2) The mechanical properties of wood free from defects vary directly with its dry weight. The relative dry weight of the different pieces of wood of any species can be approximated by comparing the proportion of summerwood in each.

(3) The only defects which materially decrease the breaking strength of timber beams are the more serious ones, such as large knots and cross-grains occurring where fibers are subjected to comparatively high stresses.

(4) All the species tested seem to be subject to the same general laws regarding the relation of mechanical to physical properties.

The rules for select structural yellow pine, quoted in this chapter, are based upon Forest Service tests and furnish an excellent example of the commercial application of the results of scientific research. Similar rules are under consideration for other woods, and in this connection it is very helpful to read the following discussion by J. A. Newlin, of the Forest Products Laboratory, originally printed in *Engineering Record.*

Fig. 25.—Pitch Pocket.

Fig. 26.—Spike Knot.

Fig. 27.—Pitch Streak.

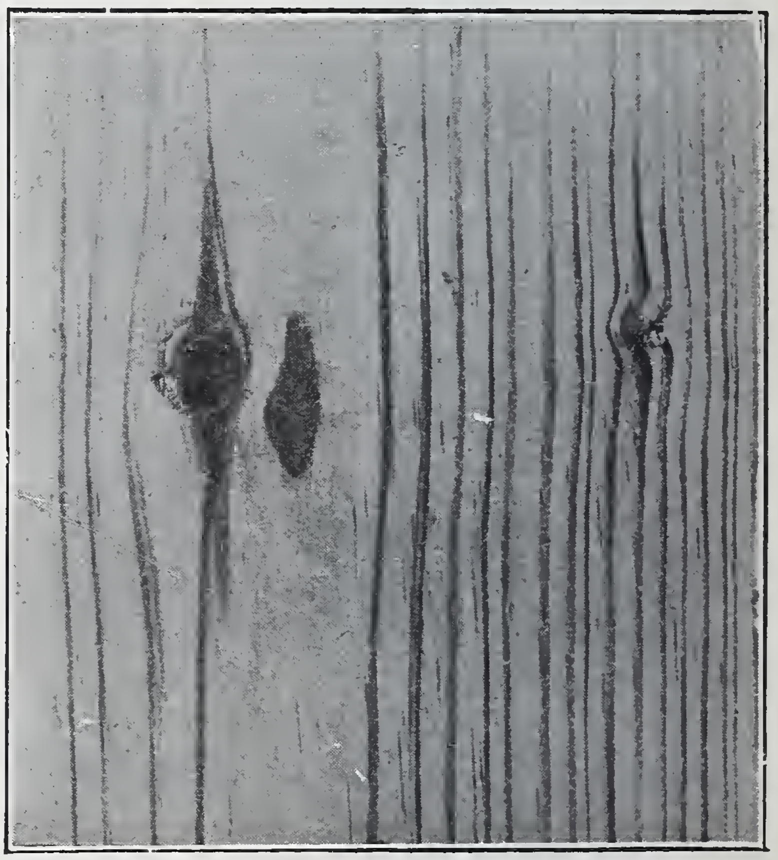


Fig. 28.—Pin Knot.

STANDARD DEFECTS

APPLICABILITY OF YELLOW-PINE GRADING RULES TO OTHER TIMBERS

In any one species of wood there is considerable variation in density and strength, this variation of course being much greater in some species than in others. In species having but comparatively little variation present conditions would not justify any density requirement. On the other hand, unless some quality classification is made in those species which show a wide range, the better material must necessarily be placed on a par with the poorer. Each of the southern yellow pines shows a comparatively large variation in density and strength. This, combined with the recognized impracticability of distinguishing lumber of these species, makes a quality classification most urgent. The rules adopted by the Southern Pine Association were formulated to establish a quality grade for southern yellow pine.

With the exception of the place where the rings are to be counted and the summerwood measured, the grading rule might be applied to Douglas fir. The modification is necessary because Douglas fir comes from large trees and much of it is not cut box heart. In fact, the grading rule itself is applicable to all species, but the criterion for dense wood is not entirely applicable to any but the southern pines.

That strength increases with increasing density is the most general law of timber physics. Not only does this law apply to different pieces of the same species, but also between the different species, with but slight variations. The best criterion of density is the weight of a given volume of dry wood. This criterion is applicable to all species and could be used in grading, although it would require a little apparatus and special training for the graders.

If a visual inspection is to be used for determining density a study of the characteristics of each species must be made in order to formulate rules applicable to the different conditions. It has been found by numerous tests that in species which show a marked contrast between the springwood and summerwood of the growth rings the proportion of summerwood gives a good indication of the density. The species having a distinct difference in springwood and summerwood and those showing no marked contrast are about equal in number, but the former class furnishes by far the greater part of the lumber produced. Important species showing a marked contrast in springwood and summerwood are the southern yellow pines, Douglas fir, larch, the oaks, ashes, hickories, etc., while the white pines, spruces, maple, beech, etc., belong to the group where springwood and summerwood are not easily distinguishable.

Summerwood in Different Species

The same proportion of summerwood in the different species does not necessarily mean equality in density or strength, as this criterion can only be used for comparisons within a given species or between those

shown by test to have equal strength values with equal percentage of summerwood. Thus in a piece of black locust and a piece of southern yellow pine containing the same proportion of summerwood the locust will invariably be the stronger. On the other hand, the difference in strength between longleaf pine and Douglas fir with equal percentages of summerwood is not very great.

The requirement of 25 per cent of summerwood for material of eight rings or more per inch is quite liberal and would admit most longleaf pine and Douglas fir. Probably more than one-half of these species would pass a 33 1/3 per cent requirement.

The relation of the rate of growth or number of rings per inch to strength is quite variable. The rate of growth in itself appears to have nothing to do with the strength, but in most species certain rates are favorable to the production of dense wood and thus indirectly furnish an indication of strength. The conifers usually have a normal rate of growth which is productive of the best material. Exceptionally fast, and, frequently, very slow, growth are likely to produce material which is lacking in density. In the ring-porous hardwoods, such as the oaks, hickories, ashes, etc., as a general rule, the more rapid the growth the denser and stronger will be the material. This rapid-growth stock goes under the name of second growth, and second growth is often specified in buying hardwoods for handles, etc. The proportion of summerwood has been used for several years in grading hickory wheel-stock.

As indicated before, the quality classification is most urgent in the southern yellow pines. The Southern Pine Association's grading rule is a step toward such a quality classification. The rule may be applied to all species, but the criterion for density must vary with the species if a visual method of determining density is to be used.

NEW STRUCTURAL TIMBER RULES

The Forest Products Laboratory has put forth a set of basic grading rules for structural timbers as a result of hundreds of thousands of tests of small clear specimens, from numerous tests of structural timbers containing defects, and from other intimate studies of the various species involved. The new rules provide for a simple classification of any or all species into four basic grades from the standpoint of strength requirements for various structural purposes, excepting columns. The difference in inherent strength and character of various species is taken care of in the recommended working stresses.

The symbols S1 (Structural 1) S2, S3, and S4 for the

grades proposed by the Forest Products Laboratory were suggested by the technical committee appointed by the Washington standardization conference of May, 1922, and these grades have generally been referred to by this nomenclature since that time. Additional names of select, standard, and common were later recommended as grade names by Committee D1 of the American Society for Testing Materials for the three most important grades, S2, S3, and S4, respectively, which leads to the suggestion of extra select for S1, the highest grade.

The Select (S2) grade is especially adapted to heavy construction, such as railroad bridge and mill work. The standard (S3) grade is primarily suitable for general building use and common mill construction. The common (S4) grade is especially recommended for small house construction where stiffness is a controlling factor, and where strength requirements are not so critical. These three grades will furnish by far the greater portion of structural timbers used. The extra select (S1) is an exceptional grade intended to meet the most exacting strength requirements for construction purposes.

The basic grades were developed primarily upon the size, number, and location of permissible defects, which are limited and classified in a practical way for different parts of a beam in accordance with the economic requirements for different classes of use. The maximum sizes of knots permissible in the four grades bear a simple relation to each other of 1, 2, 3, 4. Working stresses in the four grades have an equally simple relation, which is dependent upon the size of allowable defects. Differences between light and dense material, in the case of Douglas fir and southern yellow pine, are taken care of by increased working stresses for dense stock. The rules follow:

BASIC RULES FOR STRUCTURAL TIMBERS

Structural timbers shall be divided into four grades, namely: S-1, S-2, S-3, and S-4. The restrictions for the S-2 grade are given first since this is taken as the basic grade.

General Rules

Light Weight

All exceptionally light weight pieces in any species shall be lowered one grade.

Dense

Southern yellow pine and Douglas fir which will classify as dense under the rules of the American Society for Testing Materials for these species will be raised one grade.

Knots in Beams

The diameter of a knot on the narrow or horizontal face shall be taken as the width of the knot between lines parallel to the edges of the timber. On the wide or vertical face, the smallest dimension of a knot shall be taken. Knots on the edge of wide faces are limited to same size as on the adjacent portion of the narrow faces. Cluster knots occurring on any face in any part of a beam shall cause its rejection except when specifically permitted.

Knots in Posts or Columns

Restrictions on knots shall be based on the average diameter.

Cluster knots occurring in any part of a post or column shall cause its rejection except when specifically permitted.

Checks and Shakes

Checks, or combination of checks with shakes, which would reduce the strength to a greater extent than the allowable round shake shall not be permitted. Restrictions on shakes are given in each grade. The width of shakes shall be taken as the distance between lines parallel to the vertical edges of a timber.

Rot

All grades shall contain only sound wood unless rot is specifically permitted.

BEAMS

Grade S2

Knots

General.—Aggregate diameter of all knots within center half of the length of a beam shall not exceed the width of the face on which they occur.

Narrow or Horizontal Faces.—May have in center third of the length of a beam knot holes or sound knots not exceeding in diameter one-fourth the width of the face (maximum knot 1½ inches). Outside of the center one-third of the length, the size of a knot may increase gradually towards the end to one-half the width of the face (maximum knot 3 inches).

Wide or Vertical Faces.—Knot holes or sound knots on the edges of the wide faces shall be limited to the same size as on the adjacent portion of the narrow faces, but a knot may increase gradually in size towards the center of height to one-fourth the width of the face (maximum knot 3 inches).

SHAKES

Round or ring shakes showing on the end of a timber shall not measure more than one-fourth of the width in green material, nor more than one-third of the width in seasoned material.

CROSS GRAIN

Within the center half of a beam the slope in grain shall not exceed 1 in 15.

Grade S-1

KNOTS

General.—Aggregate diameter of all knots within the center half of the length of a beam shall not exceed one-half the width of the face on which they occur.

Narrow or Horizontal Faces.—May have in center third of the length of a beam knot holes or sound knots not exceeding in diameter one-eighth the width of the face (maximum knot ¾ inch). Outside of the center one-third of the length the size of a knot may increase gradually towards the end to one-fourth the width of the face (maximum knot 1½ inches).

Wide or Vertical Faces.—Knot holes or sound knots on the edge of the wide faces shall be limited to the same size as on the adjacent portion of the narrow faces, but a knot may increase gradually in size towards the center of height to one-eighth the width of the face (maximum knot 1½ inches).

SHAKES

Round or ring shakes showing on the end of a timber shall not measure more than one-eighth of the width in green material, nor more than two-ninths of the width in seasoned material.

CROSS GRAIN

Within the center half of a beam the slope in grain shall not exceed 1 in 20.

Grade S3

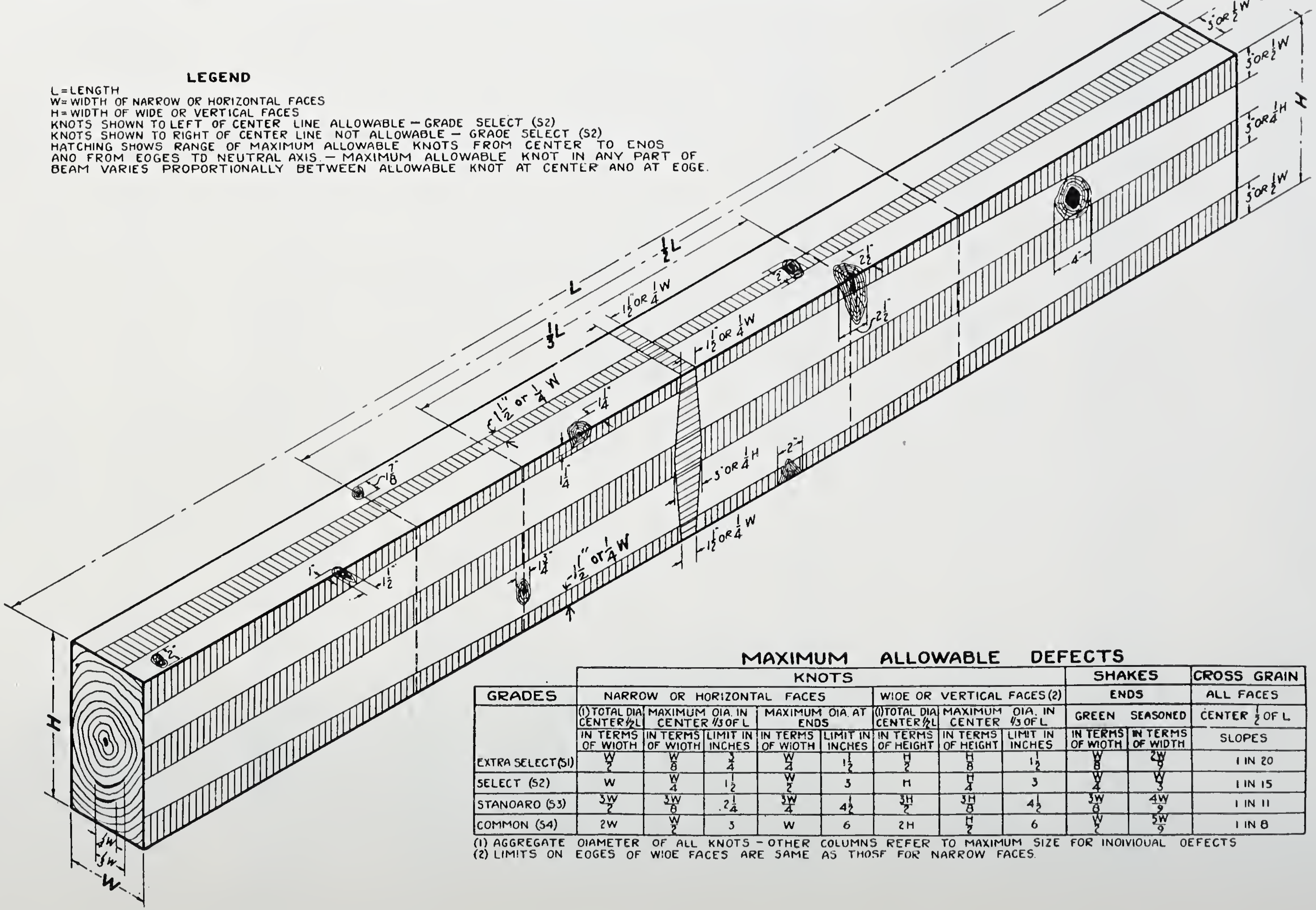
KNOTS

General.—Aggregate diameter of all knots within the center half of the length of a beam shall not exceed one and one-half times the width of the face on which they occur.

APPLICATION OF BASIC GRADING RULES TO A STRUCTURAL TIMBER

LEGEND

L = LENGTH
W = WIDTH OF NARROW OR HORIZONTAL FACES
H = WIDTH OF WIDE OR VERTICAL FACES
KNOTS SHOWN TO LEFT OF CENTER LINE ALLOWABLE — GRADE SELECT (S2)
KNOTS SHOWN TO RIGHT OF CENTER LINE NOT ALLOWABLE — GRADE SELECT (S2)
HATCHING SHOWS RANGE OF MAXIMUM ALLOWABLE KNOTS FROM CENTER TO ENDS AND FROM EDGES TO NEUTRAL AXIS. — MAXIMUM ALLOWABLE KNOT IN ANY PART OF BEAM VARIES PROPORTIONALLY BETWEEN ALLOWABLE KNOT AT CENTER AND AT EDGE.



MAXIMUM ALLOWABLE DEFECTS

GRADES	KNOTS: NARROW OR HORIZONTAL FACES: (1) TOTAL DIA. CENTER ½ L, IN TERMS OF WIDTH	NARROW: MAXIMUM DIA. IN CENTER ⅓ OF L, IN TERMS OF WIDTH	NARROW: MAXIMUM DIA. IN CENTER ⅓ OF L, LIMIT IN INCHES	NARROW: MAXIMUM DIA. AT ENDS, IN TERMS OF WIDTH	NARROW: MAXIMUM DIA. AT ENDS, LIMIT IN INCHES	WIDE OR VERTICAL FACES (2): (1) TOTAL DIA. CENTER ½ L, IN TERMS OF HEIGHT	WIDE: MAXIMUM DIA. IN CENTER ⅓ OF L, IN TERMS OF HEIGHT	WIDE: MAXIMUM DIA. IN CENTER ⅓ OF L, LIMIT IN INCHES	SHAKES: ENDS: GREEN, IN TERMS OF WIDTH	SHAKES: ENDS: SEASONED, IN TERMS OF WIDTH	CROSS GRAIN: ALL FACES: CENTER ½ OF L, SLOPES
EXTRA SELECT (S1)	$\frac{W}{2}$	$\frac{W}{8}$	$\frac{3}{4}$	$\frac{W}{4}$	$1\frac{1}{2}$	$\frac{H}{2}$	$\frac{H}{8}$	$1\frac{1}{2}$	$\frac{W}{8}$	$\frac{2W}{9}$	1 IN 20
SELECT (S2)	W	$\frac{W}{4}$	$1\frac{1}{2}$	$\frac{W}{2}$	3	H	$\frac{H}{4}$	3	$\frac{W}{4}$	$\frac{W}{3}$	1 IN 15
STANDARD (S3)	$\frac{3W}{2}$	$\frac{3W}{8}$	$2\frac{1}{4}$	$\frac{3W}{4}$	$4\frac{1}{2}$	$\frac{3H}{2}$	$\frac{3H}{8}$	$4\frac{1}{2}$	$\frac{3W}{8}$	$\frac{4W}{9}$	1 IN 11
COMMON (S4)	2W	$\frac{W}{2}$	3	W	6	2H	$\frac{H}{2}$	6	$\frac{W}{2}$	$\frac{5W}{9}$	1 IN 8

(1) AGGREGATE DIAMETER OF ALL KNOTS — OTHER COLUMNS REFER TO MAXIMUM SIZE FOR INDIVIDUAL DEFECTS
(2) LIMITS ON EDGES OF WIDE FACES ARE SAME AS THOSE FOR NARROW FACES.

Fig. 29.

Narrow or Horizontal Faces.—May have in the center third of the length of a beam knot holes or sound knots not exceeding in diameter three-eighths the width of the face (maximum knot 2¼ inches). Outside of the center one-third of the length the size of a knot may increase gradually towards the end to three-fourths the width of the face (maximum knot 4½ inches).

Wide or Vertical Faces.—Knot holes or sound knots on the edge of the wide face shall be limited to the same size as on the adjacent portion of the narrow face but the knot may increase gradually in size towards the center of height to three-eighths the width of the face (maximum knot 4½ inches).

Shakes

Round or ring shakes showing on the end of a timber shall not measure more than three-eighths the width in green material, nor more than four-ninths the width in seasoned material.

Cross Grain

Within the center half of a beam the slope in grain shall not exceed 1 in 11.

Grade S4

Rot

May contain heart rot not to exceed one-tenth the area of the cross section of the piece.

Knots

General.—Aggregate diameter of all knots within the center half of the length of a beam shall not exceed twice the width of the face on which they occur. Unsound knots to one-half the size of the sound knots are permitted in this grade. Cluster knots of the same diameter as sound knots are permitted in this grade. The diameter of cluster knots shall be measured between lines inclosing the cluster.

Narrow or Horizontal Faces.—May have in center third of the length of a beam knot holes or knots not exceeding in diameter one-half the width of the face (maximum knot 3 inches). Outside of the center one-third of the length the size of a knot may increase gradually towards the end where it may be equal to the width of the face (maximum knot 6 inches).

Wide or Vertical Faces.—Knot holes or sound knots on the edges of the wide faces shall be limited to the same size as on the adjacent portion of narrow face but the knot may increase gradually in size toward the center of the height to one-half the width of the face (maximum knot 6 inches).

Shakes

Round or ring shakes showing on the end of a timber shall not measure more than one-half the width in green material, nor more than five-ninths the width in seasoned material.

Cross Grain

Within the center half of a beam the slope in grain shall not exceed 1 in 8.

BUILDING CODES

The building codes, or ordinances, which regulate building in nearly all the cities of the country are strikingly deficient in specifications regarding timber and in most instances neither the architect nor the owner is sufficiently protected against the use of improper materials in the construction of a building. The National Lumber Manufacturers Association has made a thorough examination of the building codes of the leading cities and recommends that in the framing of such codes the following points be considered:

First: A clear definition as to building classifications.

Second: A proper limit of height for slow-burning or mill construction which will permit of its more general use.

Third: A provision calling for the filing of specifications with the Building Inspector, specifications to state clearly the quality of materials to be used.

Fourth: Quality of materials, especially lumber, to be clearly defined in the code; quality of lumber to be based entirely upon the grading rules of the manufacturers of the various kinds of lumber and to be branded with the official brand of such associations as have adopted brands; the quality of timbers, especially southern pine and Douglas fir, to be based on the density rule.

Fifth: Definite authority for building inspectors to stop operations on any building where the material used is not in accordance with the quality specified, or allowable by the code.

RECOMMENDED WORKING STRESSES

The table below gives working unit stresses for structural timbers used in dry locations, compiled in the main from material published by the Forest Products Laboratory.

Species of Timber	BENDING: Stress in extreme fibre Lbs. sq. in.	BENDING: Horizontal shear stress Lbs. sq. in.	COMPRESSION: Parallel to grain "Short Columns" Lbs. sq. in.	COMPRESSION: Perpendicular to grain Lbs. sq. in.
* Fir, Douglas				
Dense grade	1,500	90	1,100	325
Sound grade	1,300	85	900	300
Hemlock, Eastern	1,000	70	700	300
Hemlock, Western	1,300	75	900	300
Oak	1,400	125	1,000	500
Pine, Eastern White	900	80	750	250
Pine, Norway	1,100	85	800	300
* Pine, Southern Yellow				
Dense grade	1,500	110	1,100	350
Sound grade	1,300	85	900	300
Spruce	1,100	85	800	250
Tamarack	1,200	95	1,000	300

* NOTE.—The safe working stresses given in this table are for timbers with defects limited according to the sections on defects in the rules of the Southern Pine Association for select structural material. Dense southern pine and dense Douglas fir should also conform to the other requirements of this rule. Sound southern pine and sound Douglas fir require no additional qualifications, whereas the other species should, in addition to being graded for defects, have all pieces of exceptionally low density for the species excluded.

CHAPTER VIII

SEASONING OF TIMBER

Freshly cut timber frequently contains half its weight of water, or, stated otherwise, it contains 100 per cent of water based upon the absolutely dry weight of the wood. A large proportion of this excess water must be removed before the timber is in shape to use, and the process by which it is removed is called seasoning. Seasoning usually increases the strength, stiffness, and hardness of timber, greatly reduces its weight, and renders it less likely to shrink in subsequent usage. Timber is used green only when absolutely necessary, since, among other undesirable qualities, it is more likely to decay than is seasoned timber.

There are two general methods of seasoning timber—the natural and the artificial, or air-drying and kiln-drying. Air-dried timber may contain from 15 to 30 per cent of moisture, depending upon kind, size, climate, and other factors. Kiln-dried timber usually contains 5 to 10 per cent of moisture; while in what is called oven-dry or bone-dry wood, the moisture content is less than 1 per cent of the absolutely dry weight of the wood.

For ordinary structural timber, studding, sheathing, and the like, air-drying is sufficient. For the more refined uses of timber where it is re-worked into flooring, finish, furniture, and other articles, thorough kiln-drying is necessary to equalize the average indoor atmospheric conditions. Heavy material like vehicle stock may be air-dried for two or three years, and then kiln-dried slowly for a long time to obtain the necessary seasoning with the least checking and warping.

Thin boards of any kind of lumber exhibit more or less tendency to check and twist during seasoning processes. This tendency is greater in the hardwoods than in the softwoods, because of the much more complex structure of the hardwoods.

Commercial practice has, however, made such rapid strides in the last few years that almost any kind of timber is now successfully seasoned by either natural or artificial means. For many years cottonwood and gum logs were rejected by sawmill operators because of the general belief that the lumber could not be satisfactorily seasoned. Now the manufacturers handle these woods with comparatively little trouble; and their products are popular for a multitude of purposes, some of which are most exacting.

Since most of the softwoods are easily kiln-dried with little damage, many of them are artificially seasoned to reduce the shipping weight and save the time required for air-seasoning. Much of the southern pine and the Western fir and cedar go straight from the sawmill to the dry-kiln, and then into cars for shipment to market. As the hardwoods are more difficult to handle, they are ordinarily air-dried by the lumber manufacturer, and kiln-dried at the factory where they are reworked into flooring, finish, furniture, and other products.

AIR-DRYING

Lumber may be air-dried at the sawmill for a few months to a year, before it is ready to ship to consuming points. The time required to reach shipping condition depends upon weather, season of the year, kind of timber, and climate. Inch pine lumber may dry to shipping condition in two months in the Southwest in summer; while, in the damp climate of the Gulf coast, cypress manufacturers may find it necessary to hold lumber in their yards for a year to bring it to shipping condition.

Quick and satisfactory air-drying of lumber is secured by following certain principles which are recognized by all experienced lumbermen. These are to have solid foundations so that the piles will not settle out of shape; to have a good clearance above ground, and the piles sufficiently open to give free circulation of air; to have enough cross-pieces regularly placed to hold the boards straight while they are seasoning; and to give sufficient slope to the piles, and have them well covered so that water will run off quickly. A careful observ-

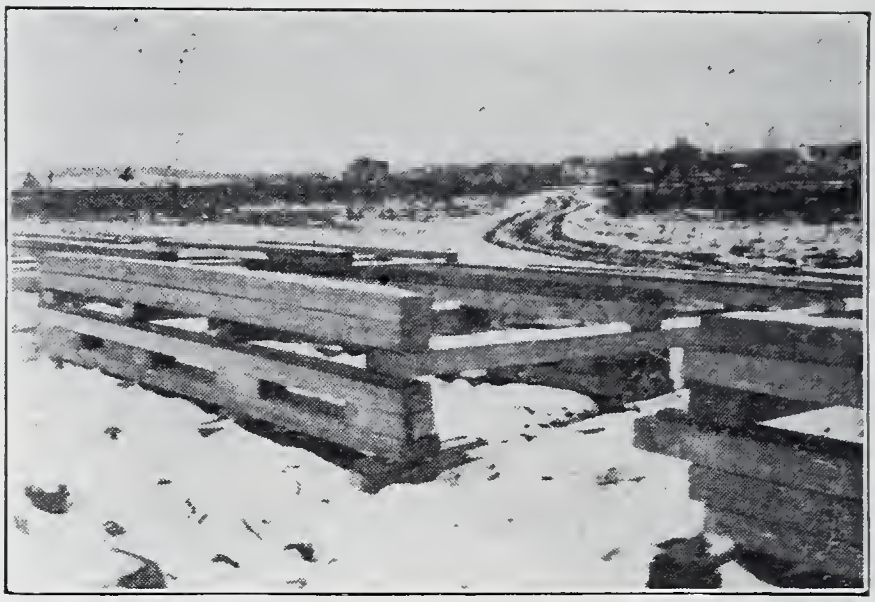


Fig. 30.—Good Foundations for Lumber Piles.

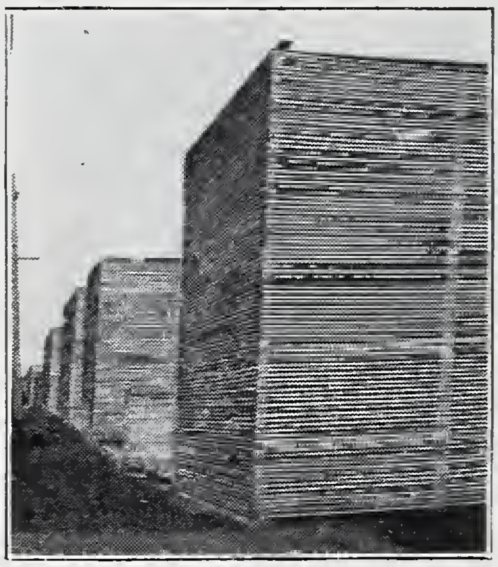


Fig. 31.—Well Piled Lumber.

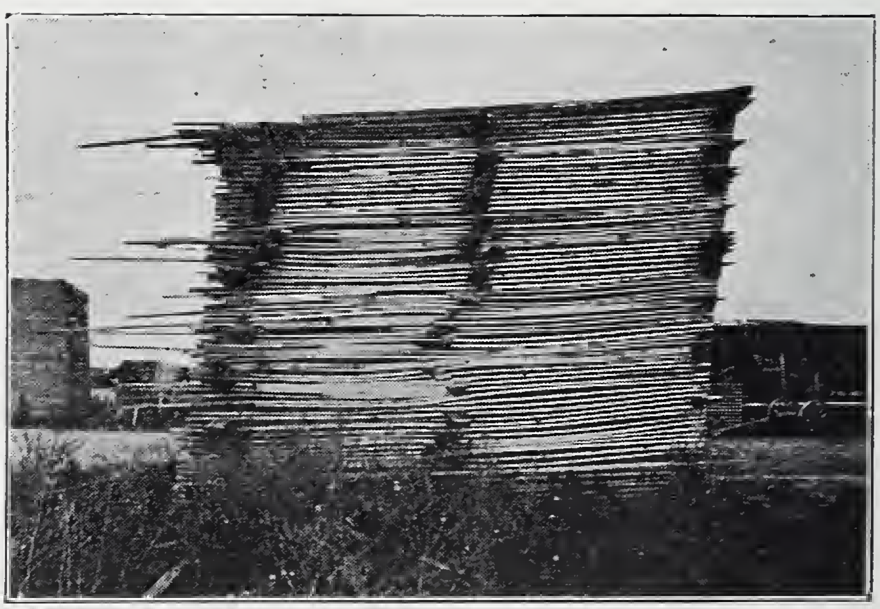


Fig. 32.—Poorly Piled Lumber.

THE AIR DRYING OF LUMBER

ance of these principles will produce straight, bright stock under conditions which would result in very poor stock if the lumber were not properly piled.

There is a common theory that if timber is cut in the winter "while the sap is down," it is much superior to summer-cut timber in strength, resistance to decay, and other desirable qualities. As a matter of fact, while there are certain advantages in winter cutting, there is absolutely nothing to the notion that the sap is "down" in winter and "up" in summer. There is practically no difference between winter and summer in the amount of water which the wood of a tree contains. Winter-cut wood seasons best because it dries out more slowly and evenly, with less checking and warping, than summer-cut wood since atmospheric conditions are more favorable in winter. It is also less liable to attacks of fungi, and molds, which produce decay or stain. Since the hardwoods are more difficult to season than the softwoods, the latter are less likely to sustain injurious effects from summer cutting. In the North, therefore, many operators saw mostly hardwoods in the winter and spring, and softwoods—pine and hemlock—in the summer and fall. However, many lumbermen cut timber the year round as it runs in the forest, and experience no special difficulty in either handling or marketing their stock.

A recent innovation in lumber seasoning for which much is claimed is a preliminary steaming in a tight cylinder before the lumber is piled in the yard to air-dry in the usual fashion. It is said that the steamed lumber air-dries much more quickly and with less checking and warping than does unsteamed lumber. It is also claimed by some that lumber cut from logs which have been in the water for some time seasons better than lumber cut from logs which go straight from the stump to the mill. Both the steaming and the water-soaking seem to dissolve some of the contents of the cells in the sapwood and open the wood up so that it subsequently seasons more uniformly.

KILN-DRYING

The artificial seasoning of lumber has made such rapid strides in recent years that it is now claimed, on good authority,

FIG. 33.—A Well-Kept Lumber Yard.

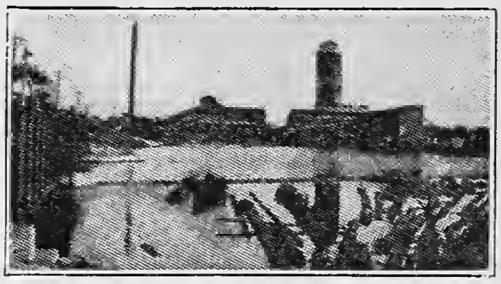


FIG. 34.—A Typical Sawmill.

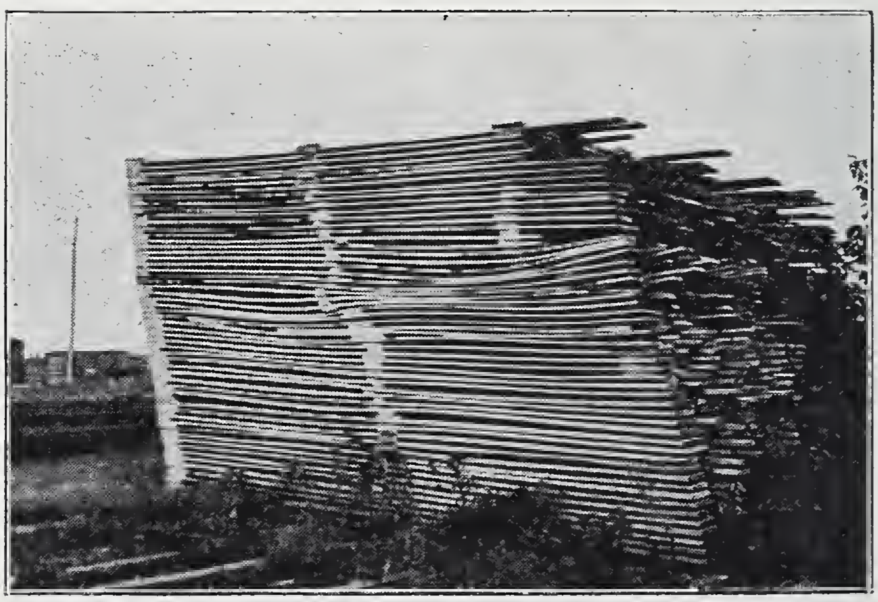


FIG. 35.—Poorly Piled Lumber.

THE AIR DRYING OF LUMBER

that lumber of almost any kind can be kiln-dried in comparatively short time, with less damage than results from air-drying. However, many users insist that only air-dried lumber is fit for the most exacting purposes. This opinion is due largely to the poor work done by the early types of kilns, which were neither scientificially constructed nor properly operated.

The rate at which lumber seasons is determined by three factors—temperature, humidity, and air circulation. All of these factors admit of regulation in a kiln; hence it is fair to assume that it is feasible to obtain favorable combinations of them which will rarely be found under natural conditions.

Kinds of Kilns.—Kilns for drying lumber are of three general types:

(1) The dry air kiln, which is now generally obsolete because it produced so much case-hardened and honeycombed lumber.*

(2) The moist air kiln, of which there are several modifications according to the methods used to regulate circulation and humidity.

(3) The kiln which uses superheated steam.

Whatever make or type of kiln is used, its successful operation requires adherence to the following principles according to the authority of the Forest Products Laboratory:

(1) The timber should be heated through before drying begins.

(2) The air should be very humid at the beginning of the drying process, and be made drier only gradually.

(3) The temperature of the lumber and the humidity must be main-

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* Case-hardening and honeycombing may be explained thus: Suppose a block of wood is very wet,-and is placed in a kiln at too high a temperature and too low a humidity. The surface begins to dry and tends to shrink, but is prevented from doing so by the wet interior. Being plastic, it yields to this resistance and becomes stretched. If not plastic, it will check open. As drying proceeds, the surface hardens and sets in an expanded condition, and acts as a strong shell. The interior now dries very slowly, does not become set, but shrinks; and, as the exterior is already hard, it opens up or ''honeycombs.'' When the exterior once becomes set or ''case-hardened,'' the interior is almost certain to become honeycombed, whether the drying takes places in the kiln or a long time afterward. The only remedy is to moisten the exterior by steaming or soaking before it is too late. Air-dried material may also case-harden and honeycomb.

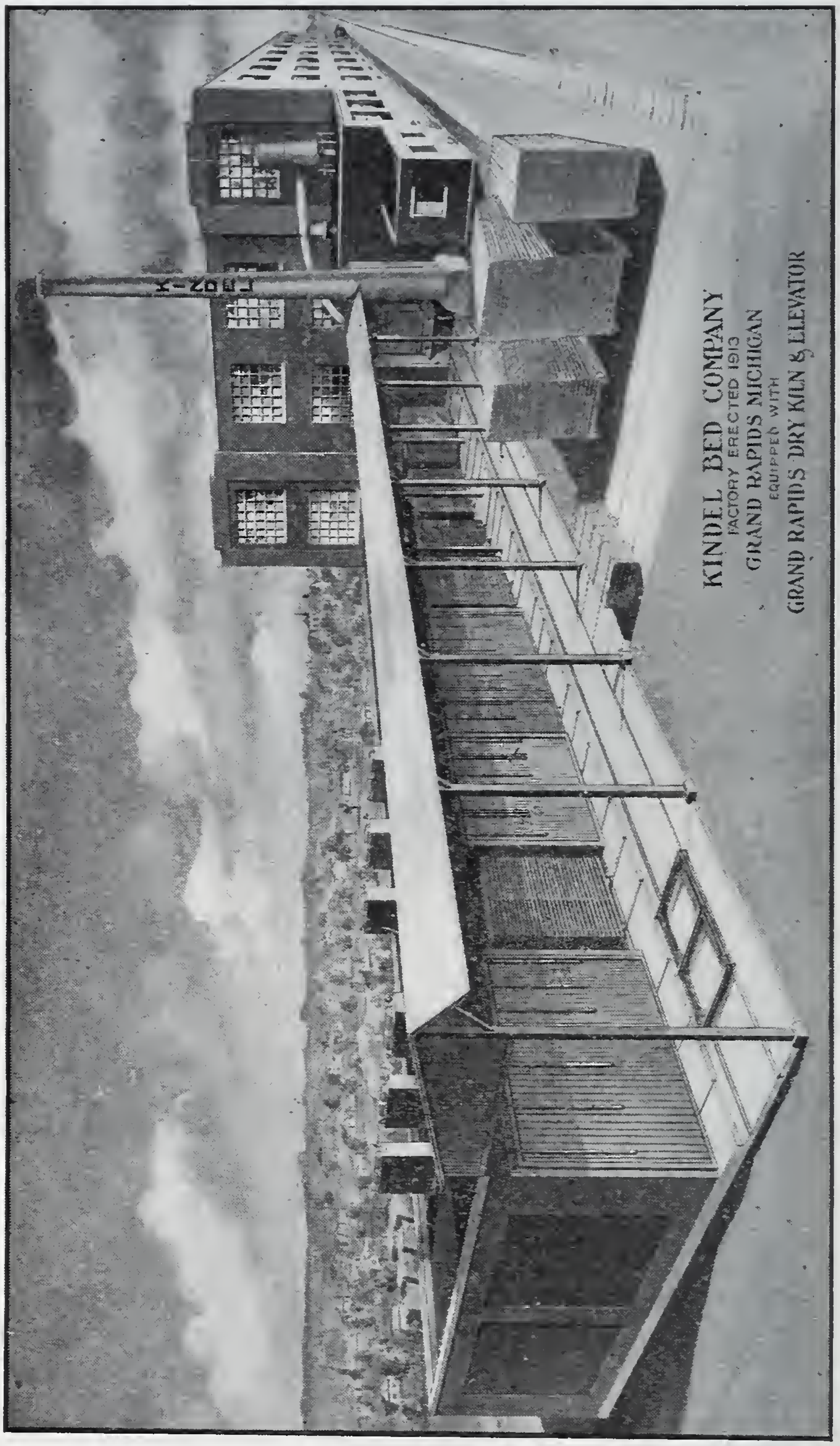


FIG. 36.—The Kiln Drying of Lumber.

tained uniformly throughout the entire pile. For this an exceedingly large circulation of air is essential.

(4) Control of the drying process at any given temperature must be secured by controlling the relative humidity, not by decreasing the circulation.

(5) In general, high temperatures permit more rapid drying than do lower ones. Temperatures as high as the boiling point are not injurious to some woods, provided the humidity of the surrounding air is great enough. Some species will not stand as high temperatures as others.

(6) The degree of dryness attained, where strength is the prime requisite, should not exceed that at which the wood is to be used.

CHAPTER IX

WOOD PRESERVATION

Some kinds of timber rot quickly after cutting; others last for many years, even under severe conditions. No hard and fast line can be drawn between woods which are durable and those which are not, since much depends upon the proportions of sapwood and heartwood, the amount of seasoning, and the situation in which the timber is used. Neither is it possible to say that any one kind of timber is superior to all other kinds in durability, or that the softwoods as a group resist decay better than the hardwoods, or vice versa.

Among the woods which are generally recognized as possessing much natural durability, are the cedars, redwood, cypress, osage orange, and black locust. Posts, poles, and ties made of these woods are often sound after many years of service under conditions favorable to decay. On the other hand, timber of naturally durable woods which is not seasoned before it is used, or which contains a very large amount of sapwood, may rot quickly, while properly handled timber of the less durable woods may last a long time. Timber like maple, gum, or birch rots quickly if used for a post or railroad tie without preservative treatment, while, if seasoned and used for house finish, it lasts indefinitely.

WHAT DECAY IS

Authorities estimate that the equivalent of nearly eight billion board feet of timber is annually destroyed by decay in the United States. This consists chiefly of lumber used for building purposes in places where most likely to decay, together with railroad ties, posts, poles, and mine timbers.

The decay of timber is caused by minute organisms called

fungi. They feed upon wood, and change it as completely as the digestive processes change the material upon which the higher forms of life feed. Sapwood is the most liable to decay, because it contains much more food for fungi than does heartwood. The latter wood often contains infiltrated substances which are more or less protective. The conditions which permit the growth of decay-causing organisms in wood are requisite amounts of heat, air, and moisture. These conditions usually exist in the most favorable combination at or just below the surface of the ground; so it is at these points that timber rots most quickly. The entire absence of either heat, air, or moisture, makes decay impossible. Timber kept either absolutely dry or absolutely wet lasts indefinitely, if not subject to wear. Sound timber found in the tombs of Egypt is an example of the former; and sound timber found in the Thames, dating from the Roman occupation of England, is an example of the latter.

HOW DECAY IS PREVENTED

Decay of timber is prevented by treating it with antiseptics, or substances which are poisonous to decay-producing fungi. There are, of course, many such substances; but practical considerations make only a few of them suitable for commercial use. One of the first essentials of a good wood preservative is that it shall not dissolve quickly when the wood gets wet or is placed in water. For this purpose the best material so far discovered is creosote, a complex product of the distillation of coal tar. For comparatively dry situations, zinc chloride is a cheap and effective preservative; but it cannot be used for the treatment of timbers which are placed in water or in continuously wet situations, because it leaches out in time. However, zinc chloride is extensively and successfully used in the treatment of railway ties. Many experiments have been and are being made with various chemicals, oils and distillation products; but thus far no other wood preservatives have been developed which are more suitable in their respective classes than coal tar creosote and zinc chloride.

FIG. 37.—House 150 Years Old, Built of Southern Yellow Pine throughout, Including Siding, and Still in a State of Good Preservation.

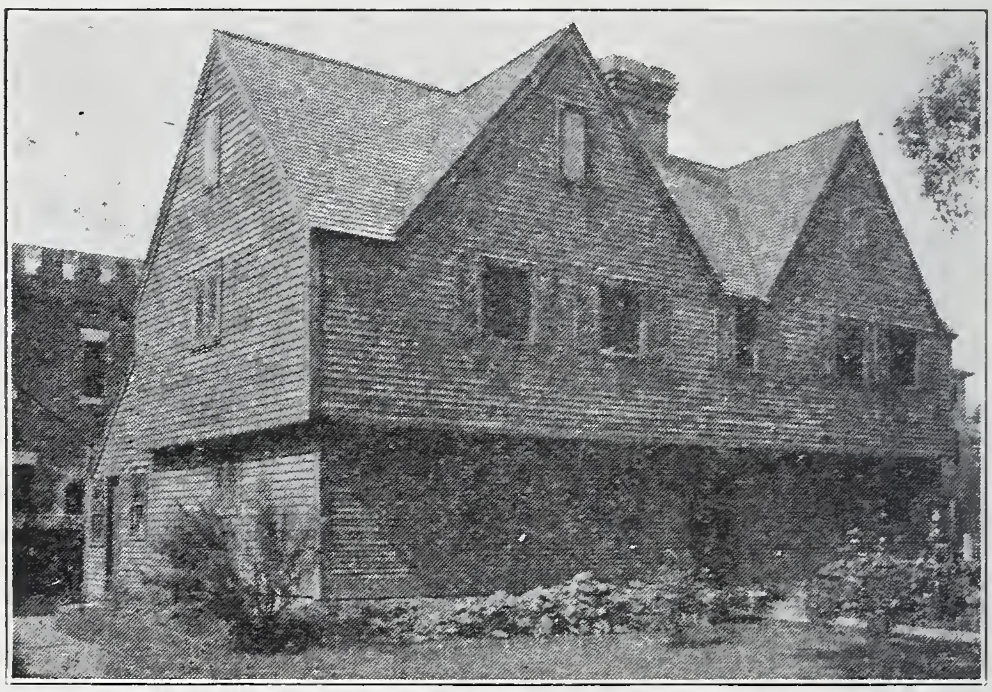


FIG. 38.—House at Salem, Mass., Sided with White Pine in 1684, and Well Preserved after 240 Years.

THE DURABILITY OF WOODEN STRUCTURES

Paint protects the surface of wood, but it does not effectively prevent decay.

The rapid growth of the timber-treating industry may be judged from the fact that the first successful wood-preserving plants in the United States were built about 1876. In 1904 there were 35 such plants; and at present there are nearly 150, with an annual output in excess of 200 million cubic feet of treated timber, of which by far the larger portion consists of railway ties, piling and telegraph and telephone poles. However, an increasing quantity of structural timber is being treated.

How Preservatives Are Applied

There are three general methods of applying wood preservatives—the brush method, the pressure method, and the open-tank method.

Brush Method.—The brush method consists in applying the preservative liberally with a brush in the same manner as paint. It is the least effective method, because of the very slight penetration obtained. It is useful, however, in cases where the preservatives cannot be forced into the wood, in painting the joints and points of contact, etc., in timbers. A slight improvement over the brush treatment is to dip the timber in hot creosote.

Pressure Method.—In the pressure process, the general features are practically the same, irrespective of the kind of preservative used. The timber to be treated is placed upon small cars, and run into large steel cylinders that are fitted with tightly fitting doors. When the wood is in the cylinder, the doors are bolted fast, and the whole made practically air-tight. In the treatment of green or wet wood saturated steam is then forced into the cylinder; and the wood is heated for two to fifteen hours, depending upon the form and kind of wood and amount of moisture it contains. At the conclusion of the steaming, a powerful vacuum is applied, and held for one to three hours. This vacuum draws out some of the moisture in the wood, and leaves it in a condition ready for the reception of the preservative. As soon as the vacuum period is ended, a valve is opened, and the preservative material is per-

Fig. 39.—Old English Blockhouse on San Juan Island. Roof of Western Red Cedar Shingles Still in Good Condition, after 65 Years' Service, without Paint or Repairs.

THE DURABILITY OF WOODEN STRUCTURES

Fig. 40.—Simple Method of Treating Butts of Fence-Posts with Creosote.

WOOD PRESERVATION

mitted to flow in. When the cylinder is completely filled with the preservative solution, force pumps are started and pressure applied until the gages indicate that the amount of preservative required has been absorbed by the wood. The liquid is then run out of the cylinder, the doors opened, and the treated material removed.

Several modifications of the process are used. With seasoned wood, the initial steaming is usually omitted, and

Fig. 41.—Wood-Destroying Fungi Growing on an Oak Railroad Tie.
WOOD PRESERVATION

the prevailing practice is to have the wood well seasoned before treatment. In the widely used empty cell process the preliminary vacuum is omitted and either a preliminary air pressure or a quick, high final vacuum is applied to recover surplus oil. This gives the same depth of penetration of preservative into the wood with 30 to 50 per cent less creosote. Another modification of the general process is the boiling of green timber in creosote under a vacuum instead of steaming.

The pressure method is the one in general use throughout the country for treating timber thoroughly and on a large scale.

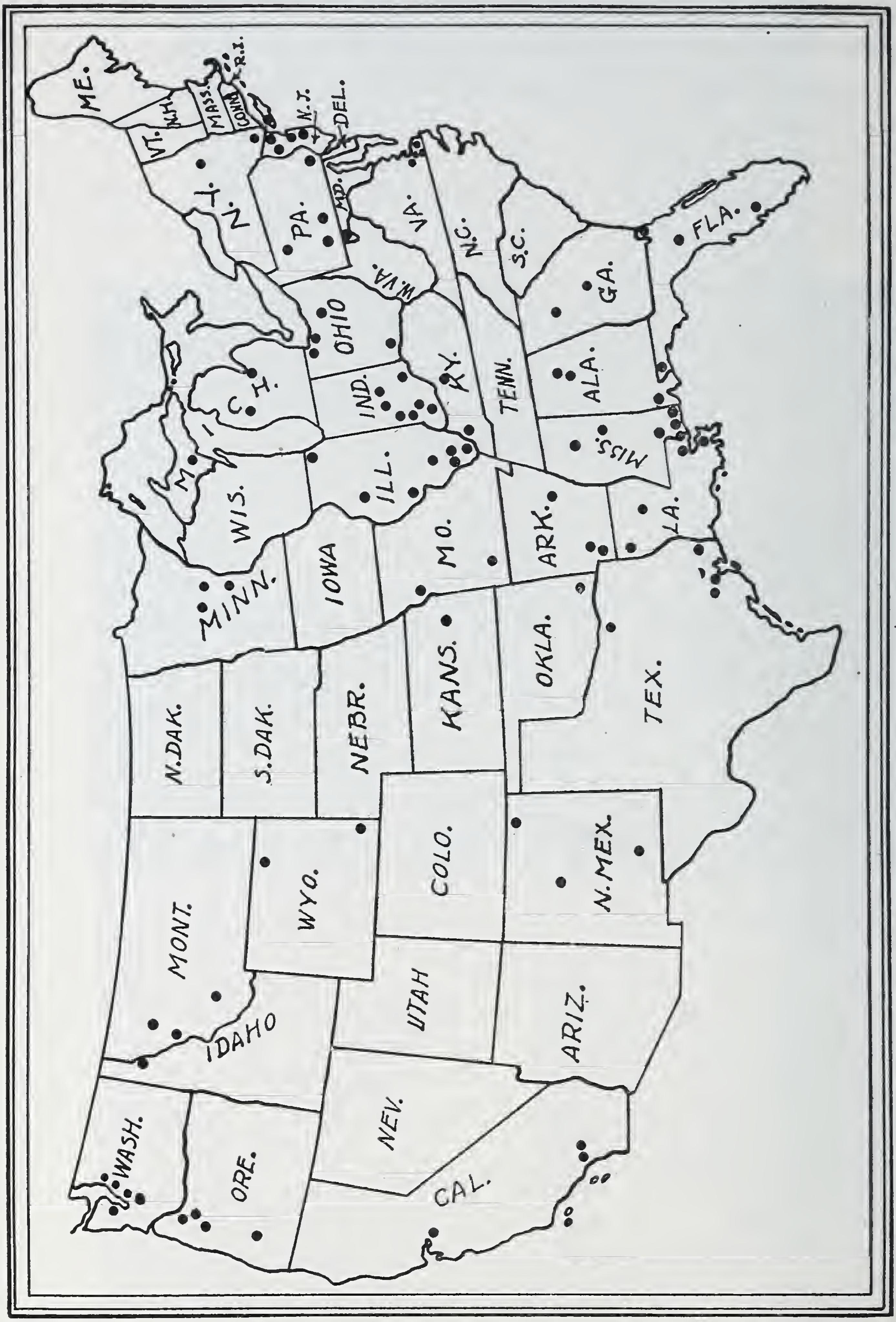


Fig. 42.—In 1921 These Plants Treated More than 166,000,000 cu. ft. of Cross Ties, Nearly 12,000,000 cu. ft. of Construction Timbers, 6,000,000 cu. ft. of Paving Blocks, over 5,500,000 cu. ft. of Piling, Nearly 11,000,000 cu. ft. of Poles, Together with Cross Arms, and Miscellaneous Lumber.

WOOD PRESERVING PLANTS IN THE UNITED STATES

Open-Tank Method.—A plant for treating timber by the pressure process is expensive, and can be erected only by firms of considerable capital. In order to devise means whereby the smaller sizes of timber, and especially posts, can be cheaply treated, the Forest Service has for many years been experimenting with what is known as the "open-tank" method.

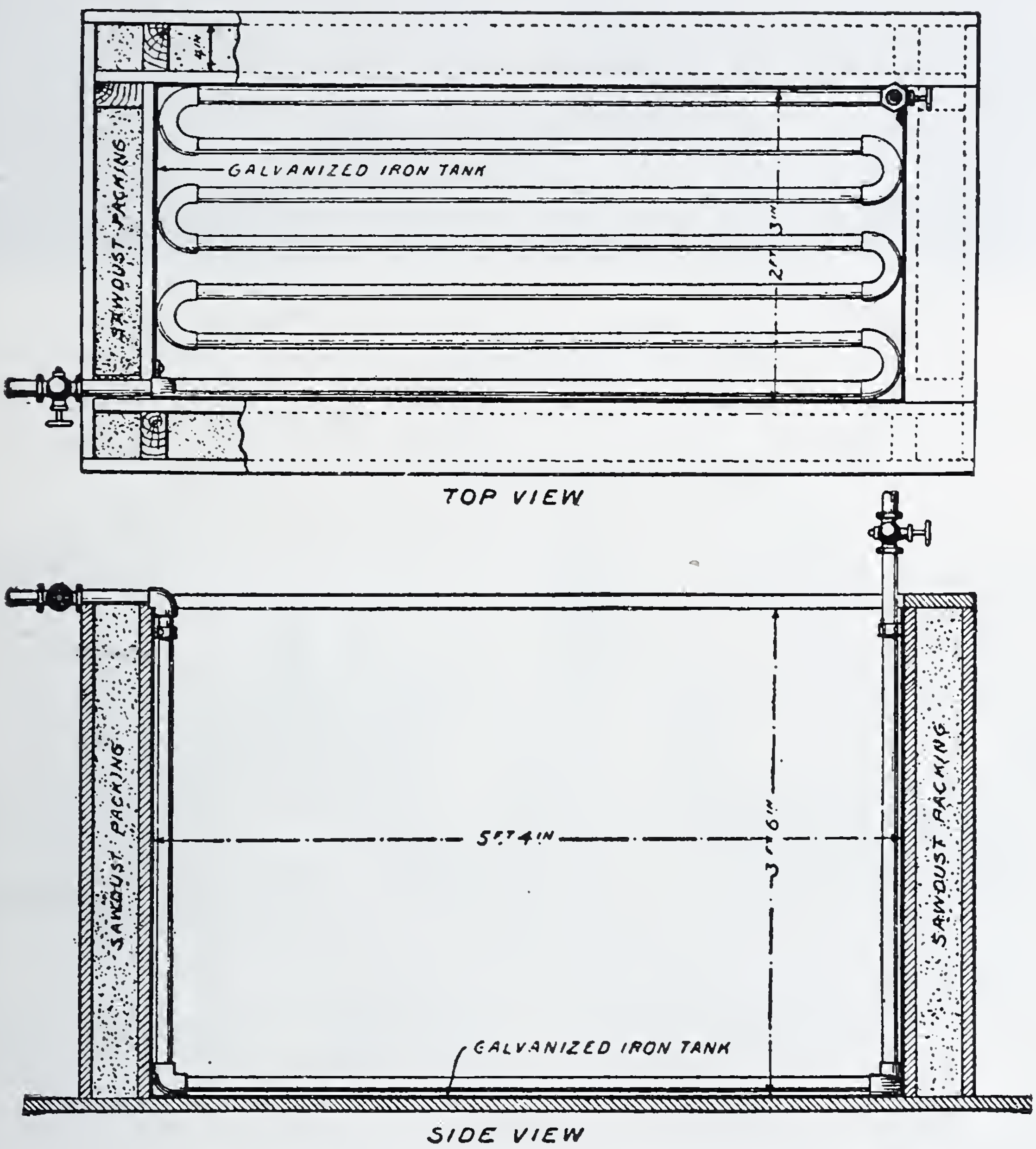


FIG. 43.—Details of Construction of Tank for Treatment of Fence-Posts.

The theory of this method of treatment is as follows: All wood is of a more or less porous nature, and contains a considerable amount of air. When placed in hot oil, for example, and heated, a part of the air and moisture contained in the wood is driven out. If the wood, while still hot, is plunged quickly into a bath of cold liquid, the small amount of air and moisture remaining in the wood will contract, and in so doing draw in the liquid.

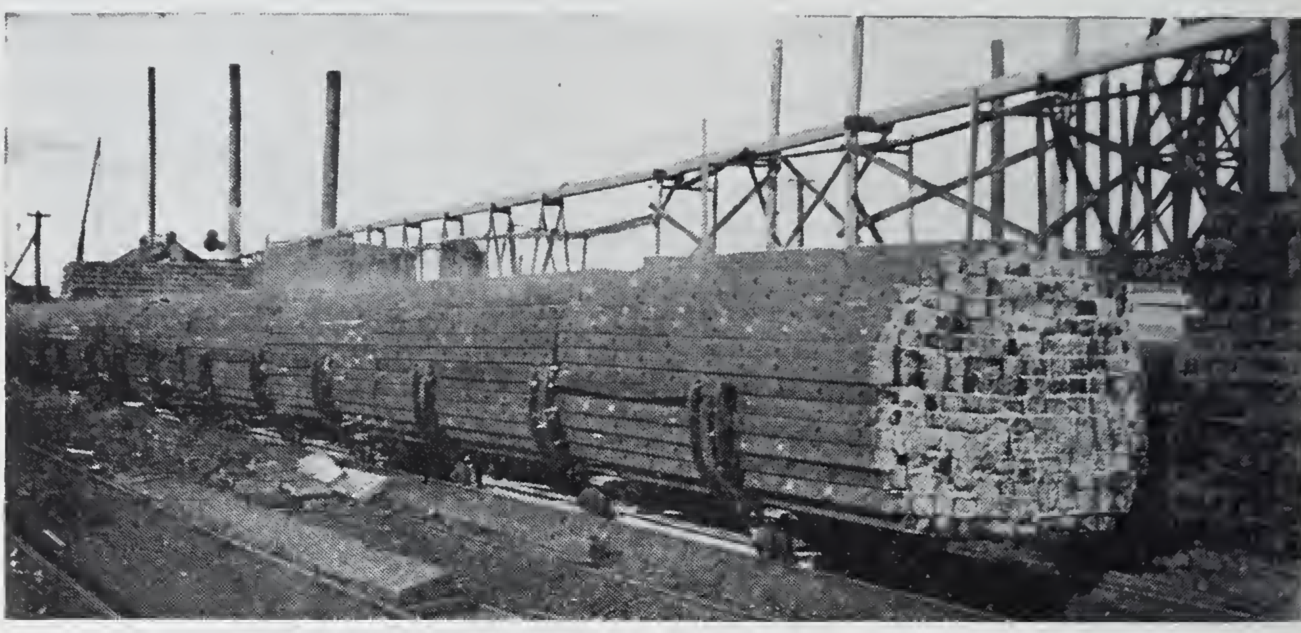


Fig. 44.—Creosoted Cross-Arms Shortly after Removal from Treating Cylinder.

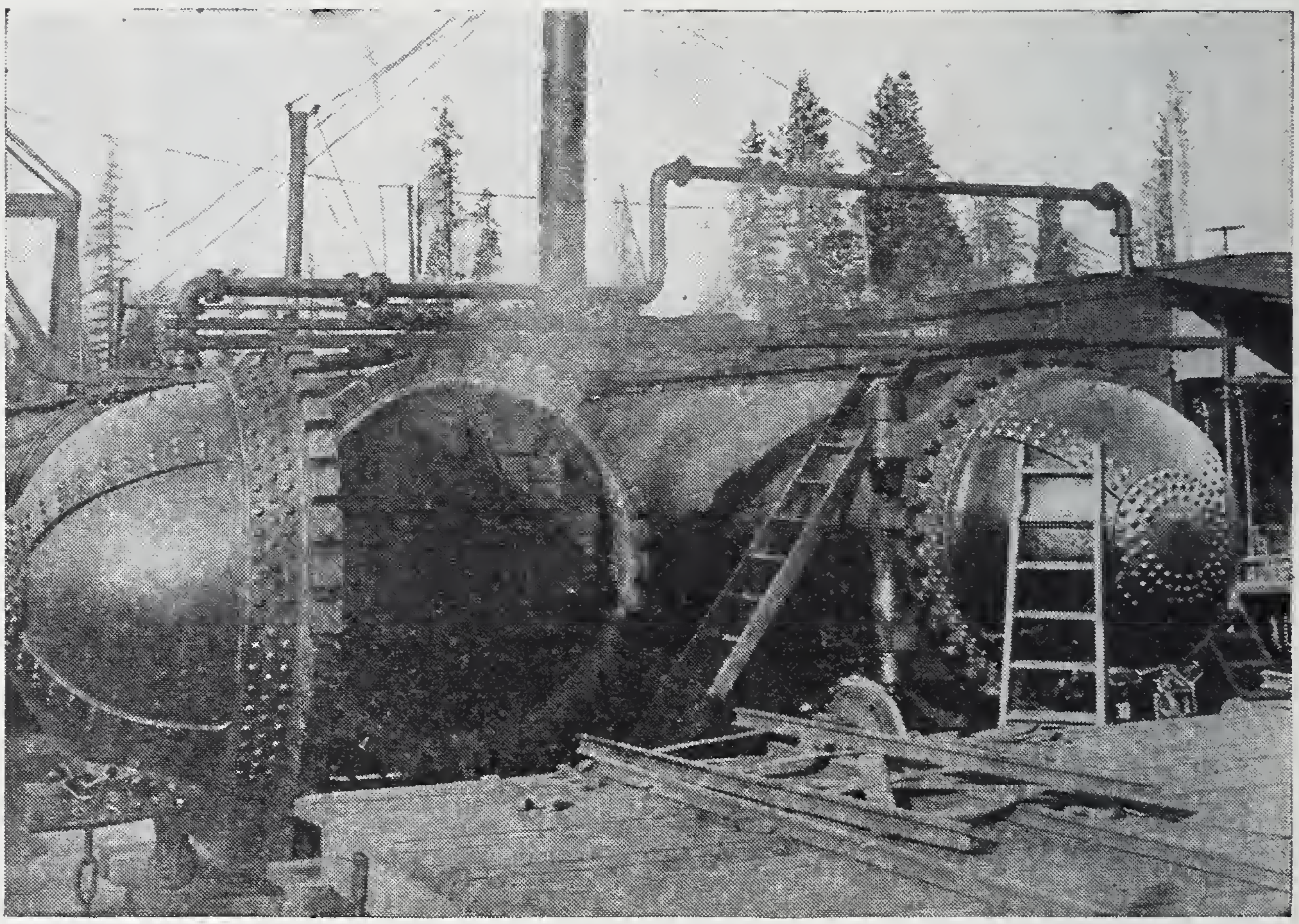


Fig. 45.—Portable Plant of Cylinder Type, for Creosote Treatment of Railroad Ties.

TIMBER TREATING BY THE PRESSURE PROCESS

If it is desired to save the expense of having two tanks—one for the hot and the other for the cold preservative—substantially the same results can be obtained more slowly by withdrawing the heat and allowing the hot tank to get cold.

A simple open-tank device successfully used by the Forest Service in treating fence posts is described as follows:

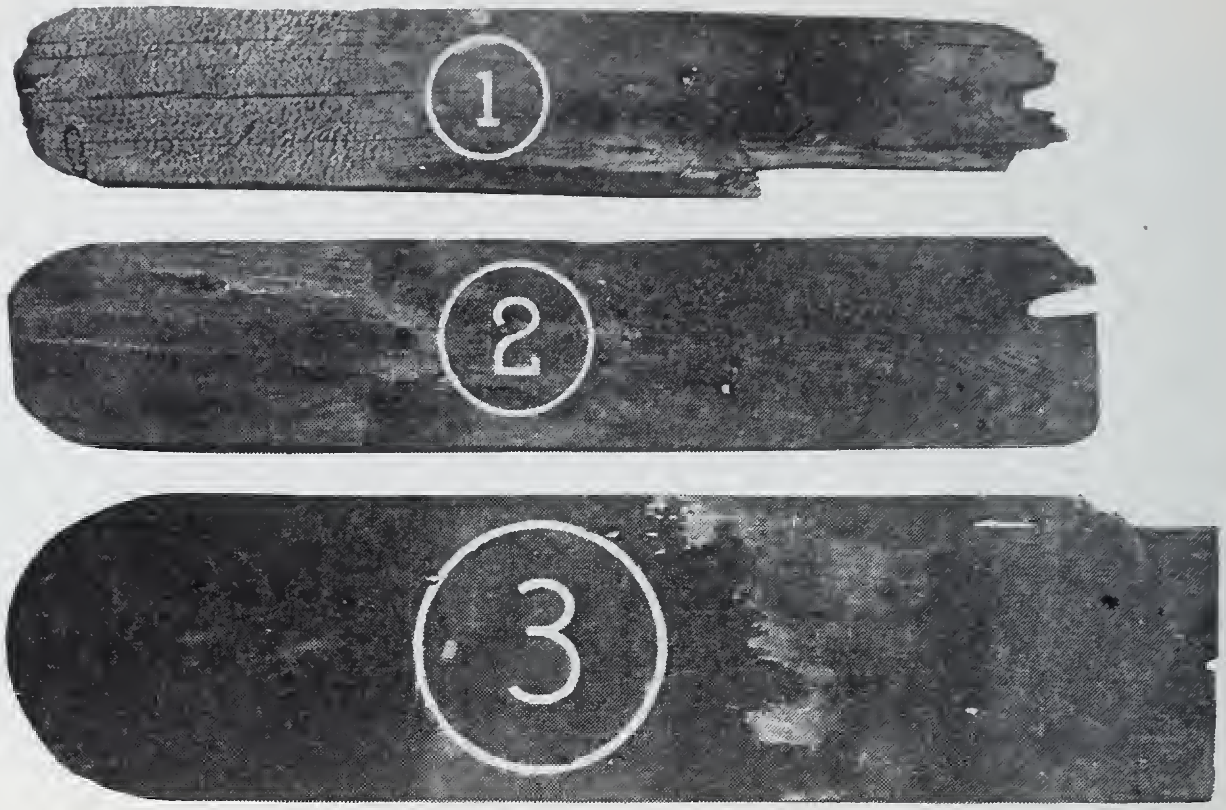
The apparatus consists of a rectangular galvanized-iron tank 5 feet 4 inches long, 2 feet 3 inches wide, and 3 feet 6 inches high. This tank is set snugly into a wooden box built of 2-inch planks and open at the top. The object of this box is to keep the tank from bulging when filled with creosote, to protect the tank from injury, and to keep the creosote from cooling too rapidly. When the posts are treated in winter or in cold regions, it is best to build an additional casing around the inner box, leaving a space of about 4 inches between them, and firmly packing this space with sawdust. The creosote will then seldom solidify overnight, and may be more quickly heated.

The creosote is heated by fitting a series of seven 1-inch steam pipes in the bottom of the tank, coupled to the boiler of an engine. The amount of steam passing through the pipes is controlled by two valves—one placed between the tank and the boiler, to regulate the amount of steam entering the coils; and the other at the outlet of the coils, to control the pressure. By raising or lowering the pressure of steam in the coils, the creosote can be heated to any temperature desired. An apparatus of this kind makes it possible to keep the temperature of the creosote fairly constant, and gives very satisfactory results. It can of course be used only when some kind of steam boiler is available. It costs from $30 to $50.

Tanks built along the lines indicated gives best results; but if means are not available for their construction, an old iron boiler or like vessel may be used. The essential requirements are that the creosote shall be heated in the vessel from 180 to 220° F., and that the butts of the posts shall be submerged up to at least 6 inches above their ground line. In special cases, where a thorough top treatment is necessary, the vessel should be of sufficient size to allow the whole post to be submerged.

The principal advantages of the open-tank method are that it is simple, comparatively cheap, especially adapted to the treating of small-sized material such as fence-posts, cross-ties, and mine timbers, and that with it practically any timber which has a fair amount of sapwood can be successfully treated.

The cost of an open-tank equipment for the treatment of posts, ties, and small timbers may range anywhere from $50 to $500 or more, depending upon its completeness.



(Photo by courtesy of Bolling Arthur Johnson)

FIG. 46.—Cypress Shingles after Long Service on Washington's Home at Mt. Vernon.

All removed in 1913. No. 1—Laid in 1743, giving 170 years' service; No. 2—Laid in 1785, 85 years; and No. 3—Laid in 1860, 53 years.

FIG. 47.—Open-Tank Method of Creosote Treatment Applied to Butts of Chestnut Poles.

WOOD PRESERVATION

Sap Staining of Timber.—The sapwood of timber or lumber cut in warm, damp weather is very likely to "blue" or stain while air-drying. This discoloration does not lessen the strength of the wood; but it does damage the appearance, and affects the market value for many purposes. Sap stain is supposed to be caused by fungi of a different kind from those which produce decay, and is preventable by comparatively simple means. If the freshly cut lumber is dipped in a 6 to 12 per cent solution of bicarbonate of soda, and then piled in open fashion so that air circulates freely among the boards, there will be practically no bluing. There are few bad effects from the soda treatment, and it is not expensive; so it has been adopted by many lumber manufacturers—especially in the South, where staining is most likely to occur. A simple device carries the lumber on an endless chain through a tank of soda solution at the tail of the sawmill.

Protection from Marine Borers.—On the sea coast, piling and dock timbers are often destroyed by marine borers, even more quickly than timber on land is destroyed by decay. The annual loss from this source is very great. In fact, in many places it is almost impossible to use wooden piles unless they are protected from borers. The best method of giving such protection is to apply a pressure creosote treatment, since creosote is as distasteful to marine borers as it is to decay producing fungi. Well-creosoted yellow pine piles have been known to give 30 years or more of service in situations where, if unprotected, they would have been destroyed in a single year. The fierceness of the attack of these borers is indicated by the examples shown in the illustration.

There is abundant evidence of the long life of creosoted wood. Even in this country, there are many examples of poles and other timbers cresoted 20 and even 30 years ago, which today are apparently as sound as when first set in the ground. In Europe, where wood preservation is an older industry, the results are still more marked. There have been failures; but in every instance they can be traced to incompetent or fraudulent work, insufficient impregnation, improper preparation of the timber, mechanical wear, or some similar cause.

Fig. 48.—Figured Red Gum.

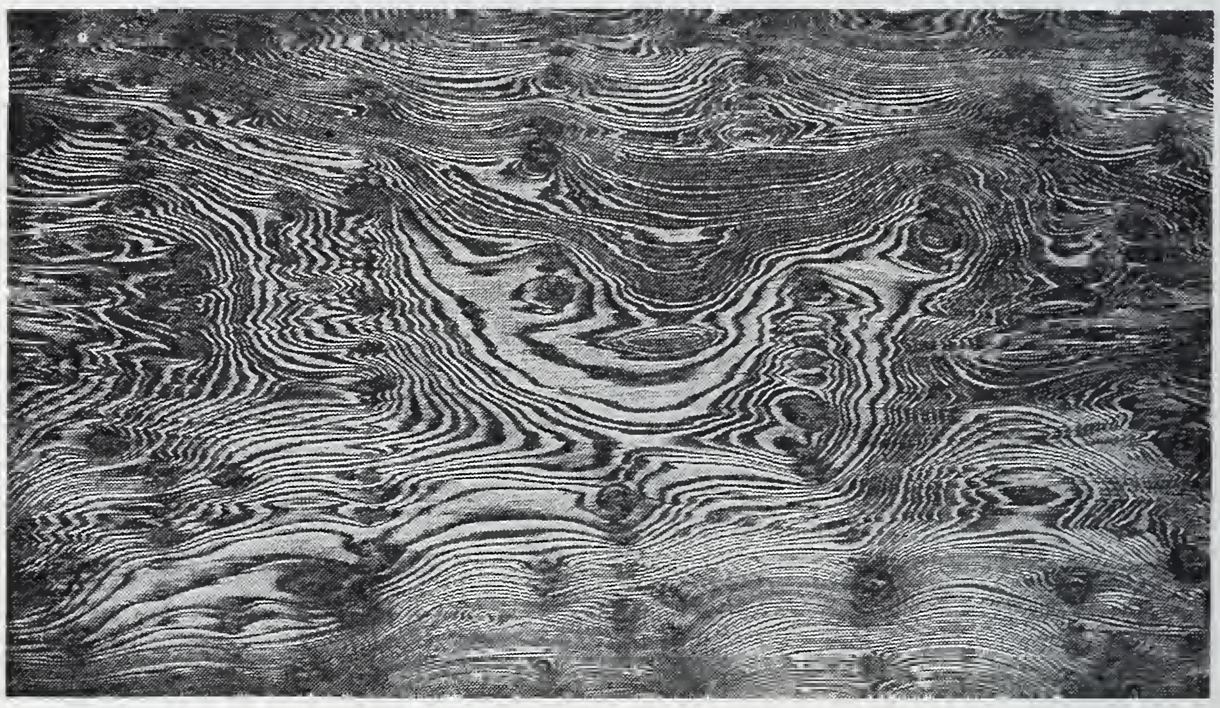


Fig. 49.—Curly Grain Cypress—Sugi Finish.

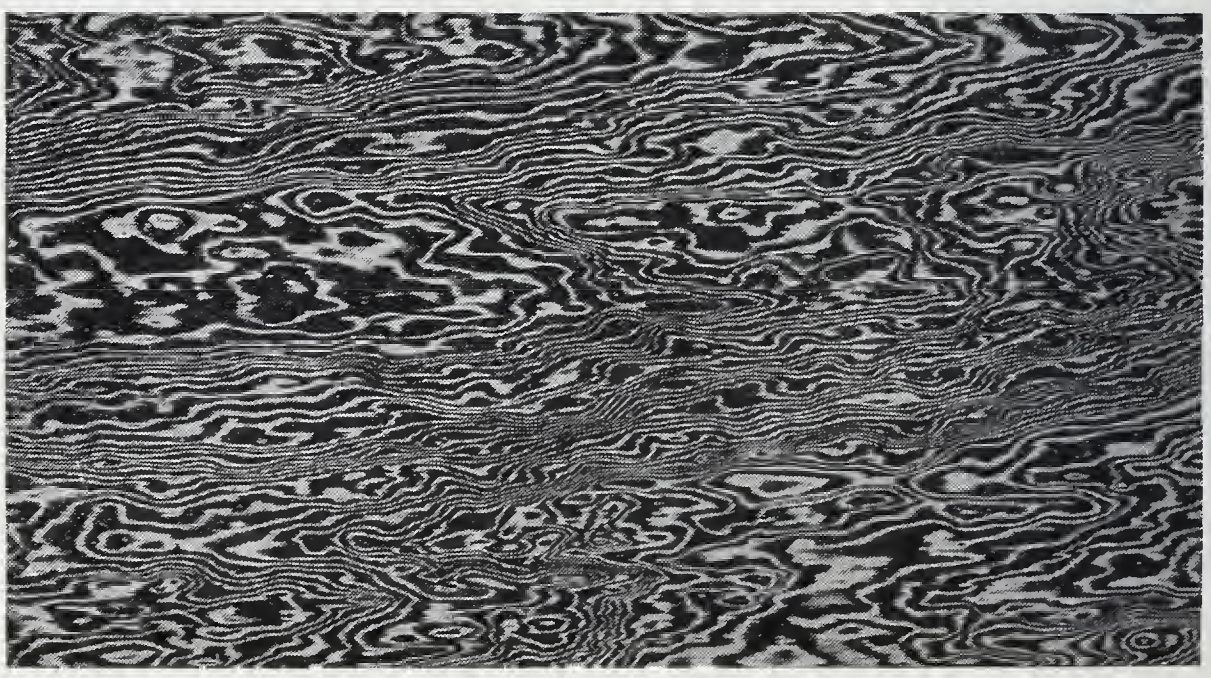


Fig. 50.—Curly Grain Douglas Fir.

FIGURES OF WOOD

CHAPTER X

PAINTS AND WOOD FINISHES

Paints and varnishes are used mainly to secure decorative effects. They reduce moisture changes and protect the surface of the wood, thus lessening checking, warping and mechanical wear. Even though well painted, wood under certain conditions will decay.

The general distinction between paints and varnishes is that a paint is an opaque covering which to a greater or less degree conceals the natural appearance of the surface to which it is applied. A stain or varnish on the other hand, either brings out more strongly the natural appearance of the wood, or modifies it to a degree depending upon the character of the stain without obliterating the natural figure. Paints are more largely used for exteriors, where protection is the chief object; stains and varnishes for interiors, where decorative features are the main consideration, although paints are also much used for interior work.

PAINTS

Paint is made by mixing and grinding certain solid substances in linseed oil or other liquids. The solids are termed pigments, and the liquid in which they are ground is called the vehicle. To these are added a wide variety of colored pigments if colored paints are desired.

The most common and the best pigments are white lead, corroded or sublimed, zinc oxide, lithopone and titanox; and the most useful vehicle, linseed oil—these forming the basis of nearly all the best paints. Turpentine is generally added to paint to make it more fluid, and hence easier to spread. Several substances called driers, usually lead or manganese salts dissolved in oil or turpentine, are also used with paint to make it

dry more rapidly. Colored paints made upon a white lead or zinc white base are most serviceable, and last longer than pure white paints. High-grade prepared paints ready for use are obtainable in any community.

A number of important points must be observed, or good results will not be secured in painting, no matter how good the paint may be. In the first place, the surface to be painted should be thoroughly clean and dry; and, if it has been painted previously, every bit of old, loose paint should be completely removed. All nail holes and cracks should be well filled with pure whiting and linseed oil putty. Knots or sappy places in the wood should be treated with some material such as turpentine which will prevent any pitch or sap in the wood from exuding and causing blisters. Paint should always be applied in thin coats well distributed. Three thin coats of paint will give much more wear than two heavy coats, and require less material. Many painters advocate four-coat work for best results. Moreover, ample time should be allowed between coats for thorough drying. Autumn is usually considered the best season of the year for painting, because of better drying and less likelihood of blisters forming in the hot sun; but with proper care, good exterior painting can be done at any time of the year.

STAINS

The finishing of interior woodwork, and particularly of the finer woods, calls for good knowledge of materials and careful workmanship. All high-class jobs of this sort require several applications and manipulations. Moreover, the finishing must be varied according to the character of the wood. The more porous or open-grained woods are usually filled with a silex paste filler which can be tinted or used with a stain, while the less porous or close-grained woods can be brought to a state of fine finish without the use of fillers.

Wood finishers usually classify oak, walnut, ash, butternut, chestnut, and mahogany as open-grained woods with which a paste filler is advisable for a fine finish; while in the class of close-grained woods, where such a filler is not necessary although sometimes used, they put birch, cherry, maple, cir-

cassian walnut, gum, white and yellow pine, basswood, spruce, fir, redwood, cedar, and yellow poplar.

Stains are usually designated as spirit, oil, or water stains, depending upon the vehicle in which the colors are mixed. Spirit stains are usually made with alcohol. Oil stains are used most largely on close-grained woods, and give a smooth finish with excellent effect. A more recent development in wood finishing is the extensive use of acid and penetrating stains which are easily applied and give many attractive effects.

After the wood is stained, the next step is the application of a finishing coat or varnish to preserve the stain. The number of coats of varnish applied depends upon the fineness of finish desired. It may be two or three on woodwork, or a large number on a high-class article like a piano case. Finishes may be gloss finishes, rubbed finishes, or rubbed and polished finishes, depending upon the manner in which applied. Moreover, there are flat finishes which produce the effect of a mission or rubbed finish without rubbing, and so are often used at a material saving in cost.

In the finishing of interior woodwork, it is especially important that the surface be absolutely smooth, clean, and dry. It is also necessary that the room in which varnish is used be kept as nearly as possible at a temperature of 70°, for varnish will not set properly at a low temperature.

There are many manufacturers of reliable paints and stains of all kinds, who will promptly supply samples of their products upon application.

SHINGLE STAINS

The popularity of bungalows and drop shingle construction has greatly increased the use of shingle stains. There are many such stains on the market, of good quality, made by various manufacturers. Several of them contain some creosote, which increases their preservative power; while any desired effect is produced by the addition of coloring matter. Shingles are often dipped in stains before laying. This is the best method of application, since the stain or preservative thus

reaches all parts of the surface, and also penetrates any openings in the shingles. A large number of shingles can be dipped in a short time, so that the cost is not great, while both the lasting qualities of the shingle and the appearance are greatly improved. (For specifications for staining shingles, see page 123.)

If a shingle stain with a lead base is desired, the following preparation published by Radford will be found useful:

A good shingle stain may be made by using pure white lead (in oil), strong chrome green (in oil), raw umber, and a little lampblack, mixed until the desired shade is reached, thinning with boiled linseed oil and a little japan. To 1 quart of this paint, add, for dipping purposes, 5 quarts creosote oil; and for application with the brush, mix 1 quart of the oil paint and 3 quarts of creosote oil. A common estimate is that 3½ gallons of stain will be sufficient for 1,000 shingles, dipping two-thirds of the shingle.

The following estimate of the covering capacity of shingle stain is based on the average cedar shingle, size 4 by 16 in.

One gallon of stain will cover 150 sq. ft one brush coat, or 100 sq. ft. two brush coats.

Two and one-half to 3¾ gallons of stain will dip 1,000 shingles, two-thirds of length of shingle to be dipped.

Three gallons of stain will dip and brush-coat 1,000 shingles in some cases.

The covering capacity of creosote bleaching oil is about one-fifth less than the above figures.

The protection of shingles from fire by means of special paints is discussed in the chapter on "Fire Resistance."

ARCHITECTURAL SPECIFICATIONS FOR PAINTING, STAINING, ETC.

Architectural specifications for the painting, enameling, staining, and finishing of woods for first-class and medium grades of work, prepared by Mr. John Dewar at the request of the Master House Painters and Decorators of Pennsylvania, were endorsed by that Association, January 15, 1913. The essential portions of these specifications are quoted as follows:

Painting New Exterior Woodwork

Medium.—All knots, rosin, and sap portions shall be properly shellacked.* Paint one coat white priming brushed well into the wood, after which all nail-holes, open joints, and other imperfections shall be closed solid with putty containing 20 per cent white lead; then apply two coats of paint, colors to be selected. Each coat must be thoroughly dry before the application of another. Paint the back of all window and door frames one coat before setting, sash runners of window frames to receive two coats of oil, stained if required, the last coat to be applied at completion. No paint to be applied during wet or foggy weather. (See Note 1, below.)

First-Class.—Wood work should be painted as above specified, using one additional coat.

NOTE 1.—All authorities agree that pure raw linseed oil and pure spirits of turpentine are the best vehicles for exterior paints. The vehicle of first or priming coat on new wood, also second coat, should consist of 80 per cent pure raw linseed oil and 20 per cent pure spirits of turpentine, the final coat 90 per cent pure raw linseed oil and 10 per cent pure spirits of turpentine, all to contain necessary driers. When four coats are used, the first, second, and third coats should be composed of 80 per cent oil and 20 per cent turpentine, the fourth coat 90 per cent oil and 10 per cent turpentine.

Some diversity of opinion exists as to the best paint pigment or pigments in combination. Efforts should be made to have the construction of a paint film as near perfect as possible. The necessity of this should be apparent to us all, especially when we are confronted with the fact that "the average paint coating is only three one-thousands of an inch thick, and yet this thin coating is required to withstand expansion and contraction of the underlying surface, abrasion or wear from storms of dust and sand, or rain, sleet, hail, and absorbing, drawing, and expanding influences of the summer's sun, and contraction from the cold of winter. It must have both hardness, to withstand to a reasonable extent this surface wear, and yet enough elasticity to meet internal strain and to conform to changes in the underlying surface; and it must penetrate and cling to the surface upon which it is applied. It must also retard and prevent from access to the underlying surface both the moisture and atmospheric gases which cause decay;" and, if possessing the virtues of a good paint, it must in the course of time, when repainting becomes necessary, present a suitable foundation for the new paint coating.

It is generally accepted that a white or tinted base paint containing about 75 per cent white lead and 25 per cent zinc oxide is a high standard. When used near or at the sea shore, also in the Southern states, it can be improved by a change to the following: 60 per cent white lead and 40 per cent zinc oxide. The purpose in combining these two best paint pigments are, that the one makes strong the weak points of the other, giving us an ideal paint coating. The zinc makes the film stronger and harder, also practically non-absorbent by reason of these qualities, and, with its fineness of texture, fills up the voids

* The more modern method is to omit the shellac and treat with turpentine before applying the paint.

caused by the coarser pigment. After a most thorough and practical personal investigation as to results, I recommended the above combination, having used them in my practice for years. I have the manufacturer combine and grind the two pigments together, thereby getting a thorough amalgamation.

When the result required is a white or color-tinted paint, it is advisable to use the same percentage of different basic pigments and coloring matter in all of the coats, on account of obtaining a uniform expansion and contraction, solidity of color, etc.

When prepared mixed paints in paste form are used, the limit of inert pigments should be 15 per cent. This percentage may be composed of barytes, silica, or asbestine, or a mixture of such pigments. To this amount there should be no objection, as, up to that extent, these inerts have their values as part of a good paint film; but vehicle proportions as set forth should be followed.

The use of asbestine is principally to hold up in suspension the heavier pigments in the paint, its fluffy and rod-like form being valuable for this purpose. It is also said to act as a reinforcing pigment in the same way that iron bars act in reinforcing concrete structures.

Note.—High-grade prepared paints made on a lead and zinc base are the most economical for use on all exterior surfaces. They come in prepared form, ready for use, and are obtainable in any desired color or shade. Their serviceability is much greater than that of the usual hand-mixed paints.

Straight white lead makes a splendid primer. Ochre should never be used, nor boiled linseed oil for under-coatings. When the color of the finishing coat is required to be a strong solid color such as green, red, etc., by using these strong colored paints from the foundation up, you will not get a solidity of body; therefore I would suggest the use of a strong tinted white base for under-coatings.

In the painting of cypress and Southern yellow pine, the vehicle in the priming coat, and priming coat only, should be 40 per cent of 160 degree benzole, 10 per cent pure spirits of turpentine, and 50 per cent pure raw linseed oil, proceeding with the subsequent coat as specified above. The character of these woods is such as will not permit of the penetration of paint made by the usual vehicle practice. With the turpentine and the addition of benzole, which is one of the greatest penetrating solvents of rosin, gums, and grease known, they carry the oil and pigment, when well brushed out, into the wood; and it there finds a lodgment, forming a substantial and permanent foundation for the subsequent coatings. The benzole, like turpentine, after performing its mission, evaporates entirely, leaving no residue.

From the beginning to the finish of a first-class residence, or other important operation, considerable time may elapse, not infrequently a year or more, therefore a necessity for the additional or fourth coat of paint. I would recommend for their distribution, after the priming or first coat and the necessary puttying up, that the second coat be applied, the third and fourth coats about the time of completion of building. Another substantial reason for the fourth coat is that the householder, realizing that he has a new residence, is usually less watchful as to any necessity for repainting for a term of years.

With the application of the priming coat when the work is first put in place, followed by the two coats probably six months or a year after, such a condition will of necessity require repainting in probably less than four years. This proves the economy of the fourth coat, which, under average conditions, lasts as a protective agency for probably six or seven years before the necessity arises for repainting.

Repainting of Exterior Woodwork

Remove such old paint as may be necessary from exterior woodwork by scraping, burning, or with paint remover as conditions may require. Sandpaper and touch up with one or two coats of paint as found necessary all of that portion from which the old paint has been removed. Paint all woodwork two coats, colors to be selected. Do all necessary sandpapering and puttying. (See Note 2.)

NOTE 2.—In the work of repainting, it is practically impossible to specify intelligently without being familiar with conditions, as so much depends upon them.

The basic paint pigments should be as specified in Note 1. The proportions of vehicles for first coat must be determined by conditions. For instance, if the vehicle of the old paint coatings is dried out, leaving an absorbing surface, hungry as it were, the vehicle for first coat should consist of about 75 per cent raw linseed oil and 25 per cent turpentine, second or final coat 90 per cent raw linseed oil and 10 per cent turpentine; or, if the surface be hard and non-absorbing, the proper proportions of vehicle for first coat should be about 50 per cent oil and 50 per cent turpentine, the final coat 90 per cent oil and 10 per cent turpentine. Not infrequently I have found it necessary in repainting, from a number of causes, to give all of the woodwork three coats.

The overcoming of these differing conditions and producing the best results possible, is largely a work of diagnosis consisting of about 75 per cent man and 25 per cent material. The remedy for the several ailments consists in varying proportions of the vehicle to meet the diversified conditions, and not with the pigments.

The paint burner ever being a menace, I would discourage its use where possible. In every instance I would have the owner of the building give his consent to its use; also that he notify his insurance company, and get a permit from it consenting to its use.

Staining of Exterior Woodwork

Medium.—All exterior woodwork (or a portion as the case may be) to receive one coat of linseed oil stain, brushed well and uniformly into the wood. Color to be as required. Pigments to be selected for their permanency of color. Vehicle to consist of 40 per cent of 160 degree benzole and 60 per cent raw linseed oil; all nail-holes and other imperfections to be closed with lead putty colored to match stain; then apply one good coat of raw linseed oil containing 10 per cent turpentine. (See Note 3.)

First-Class.—Specify one additional coat of oil containing 10 per cent turpentine. (See Note 3.)

Staining Shingles.—Dip shingles two-thirds their length in stain specified as above, color to be determined. After shingles are in position, touch up and apply one coat of linseed oil containing 10 per cent turpentine. (See Note 3.)

NOTE 3.—This stain is suitable for all kinds of wood used for exterior finish. It must be remembered that a stain implies a trans-

parent coloring, and not a paint coating which is opaque. If it is desired to stain oak or cypress to a dark green or a dark brown color usually used on the timbering and finish of houses designed after the old English period, two coats of stain should be specified to get the necessary depth of color. To attempt this with one coat would result practically in a paint coating, with a covering or hiding of the figure of the wood. If it is desired to stain oak a silver grey or other light colors, but one coat is necessary. Shingles, owing to depth of color required, frequently require a second coat of stain after they are set in place. The use of benzole in the stain becomes the active penetrating factor, carrying the coloring matter and oil into the wood. It has about the same evaporating consistency as turpentine.

There being a substantial difference between a paint coating and a stain, therefore the stain specified can be used when necessary for both coats.

Where a perfectly flat surface is desired, the second coat of oil may be an objection; but for durability I would recommend it, also for the reason that the oil gloss shortly flattens down.

A number of very good shingle stains are on the market.

Re-Staining of Exterior Woodwork

Prepare and re-stain all or such portion of exterior woodwork as may be found necessary, color conforming closely to original stain. Coat all stained woodwork with two coats of linseed oil containing 10 per cent turpentine. Between first and second coats, close up all imperfections with putty colored to match stain. (See Note 4.)

NOTE 4.—Re-staining is also a work of diagnosis as to whether the entire work should be gone over with a light coat of stain, or a portion, where the former is badly used up, and whether it should have one or two coats of oil. In this case an examination will quickly determine the action. A coat of oil over the old stain will make quite a difference in appearance of old color.

Plain Painting for Interior New Woodwork

Shellac all knots and sapwood; paint woodwork (locating same) three good coats, color to be selected. (After the first or priming coat, close up with lead putty all nail-holes and other imperfections. Do all necessary sandpapering between coats.) (See Note 5.)

NOTE 5.—If color required be white or lighty tinted, the woodwork should first receive one coat of shellac to prevent discolorations from resin and sapwood. If varnish coat should be required over paint, specify all painted work to receive one coat of a good wearing light color varnish, evenly applied.

Painting and Graining Interior New Woodwork

Shellac all knots and sapwood; paint all woodwork (locating same) two coats, no oil to be used in this paint other than that in which the lead is ground. In mixing, use a small quantity of a good mixing varnish, thinning with turpentine so that the paint will dry with a flat eggshell gloss, sandpapering each coat perfectly smooth.

Grain in best manner in imitation of hardwood to be selected, the graining color to be used as flat as possible, consistent with working out. Varnish all grained work one coat of a good wearing body varnish. (See Note 6.)

NOTE 6.—If a first-class job is required, specify one additional coat of varnish to be full and evenly applied, each coat to be thoroughly dried before the application of another. If a flat finish is required, specify the last coat of varnish to be rubbed evenly to a flat finish with crude oil and pumice stone, all oil and pumice stone to be thoroughly cleaned off at completion.

A flat finish may be secured by using what is termed a "flat varnish." In the use of a flat varnish, two coats are required, the first being a gloss varnish. About 50 per cent of these varnishes contain a large percentage of wax over which you cannot apply at any future time paint or varnish, as neither will adhere permanently to a wax surface. The use of some of these flat varnishes is commendable, especially in producing certain results on natural hardwoods.

Graining is practically becoming a lost art, owing to the general use of hardwoods. Where the work is well done, this specification should produce splendid results. Some painters may not agree with me in the number of coats and manner of mixing the ground coating; let them try it, and they will find no cracking or crazing of their varnish; but of course the varnish must be good, and undercoating perfectly dry.

Woods best adapted to painting and graining are birch, cherry, maple, poplar, and white pine.

Natural Finish for New Interior Softwoods

All woodwork shall be thoroughly gone over, cleaned up, and sandpapered where necessary, after which apply one coat of white shellac and two coats of a good wearing body varnish, the last coat to be evenly flowed on. After shellacking, close up all nail-holes and other imperfections with putty colored to match wood, being careful to rub off any surplus putty. Sandpaper thoroughly between coats. (See Note 7.)

NOTE 7.—This would apply to white pine, poplar, yellow pine, cypress, etc. Sometimes a flat finish is required; in that case, specify rubbing with oil and pumice stone to a dull even finish. I do not recommend close rubbing on two coats of varnish, as it must be kept in mind that close rubbing will practically remove one coat of varnish. I do not recommend any rubbing for servants' quarters, nor yet for the average medium job.

The natural color of these woods is sometimes an objection. In that case I add a touch of burnt sienna, or burnt and raw sienna, to the first coat of varnish, not sufficient to produce a stain, simply giving the wood a warm pleasing glow, removing the harshness of the natural color.

Staining and Varnishing New Interior Softwoods

All woodwork shall receive one light coat of 25 per cent linseed oil and 75 per cent turpentine. Sandpaper and stain in best manner with an oil stain containing about 50 per cent turpentine; color to be

selected. Close up all nail-holes and other imperfections with lead putty colored to match stain, being careful to wipe off any surplus putty marks. Varnish all stained work two good coats of a strong wearing body varnish, the last coat to be evenly flowed on. Sandpaper between coats, each coat to be thoroughly dry before another is applied. (See Note 8.)

NOTE 8.—The purpose of applying a thin coat of oil to the woodwork before staining is that certain portions of the surface may be very much softer than others; in fact it may appear in spots, all over. With the application of the oil as specified, you in a measure stop the suction of those soft places, and get a practically uniform surface on which to work the stain. A thin coat of shellac instead of the oil might be used, but I prefer the oil as thinned with the turpentine, as I get a more uniform absorption into the wood for the stain, the shellac in a measure stopping absorption.

For a flat surface I would specify rubbing with oil and pumice stone to a dull finish; for close rubbing I would specify one additional coat of varnish. This specification would apply to white and yellow pine, poplar, cypress, etc.

Painting and Enameling Interior New Woodwork

Medium.—All woodwork (specify location) shall be gone over carefully. Shellac all knots and sap portions. Prime with one thin coat of white paint, well brushed into the wood, after which sandpaper thoroughly, closing up all nail-holes and other imperfections with lead putty. Apply one medium coat of pure grain alcohol white shellac. Sandpaper lightly. Apply three coats of white paint consisting of about 60 per cent white lead and 40 per cent zinc oxide, and one coat of straight pure zinc oxide, followed by one coat of best enamel, freely and evenly applied, all coats to be tinted as required. Each coat must be thoroughly dry and well sandpapered before the application of another. (See Note 9.)

First-Class.—Apply one additional coat to the above specification (four coats) after the shellac, followed by the straight zinc and two coats of best enamel, the last coat of enamel to be evenly rubbed with water and powdered pumice stone to a satin or china gloss finish. (See Notes 9 and 10.)

NOTE 9.—With the application of a second coat of enamel this specification may be rubbed with water and powdered pumice stone to a very good finish. If a semi-gloss or flat finish is desired with but one coat of enamel, reduce the enamel by mixing into it a portion of the straight zinc coater necessary to give the condition required. To fully obtain this result requires very careful brushing, so as not to show laps, brush marks, and cording; but it can be accomplished very nicely.

With the exception of the priming coat no oil should be used except such as may be found in the stiff lead and zinc; the priming coat should consist of about 40 per cent oil and 60 per cent turpentine, light of body and well brushed into the wood. I have my zinc for

enameling purposes ground in poppy oil, which greatly minimizes the chances of the work turning yellow when confined to a dark room. The use of linseed oil is a strong factor in the work turning yellow when excluded from a strong light. In the preparation of my several under paint coatings, I use, instead of oil as a binder, a portion of a good mixing enamel varnish; each coat must be worked flat. In using the straight zinc oxide for a final coat of paint on this class of work, I find that I can get purer tints of greater variety, without the danger from chemical action that would result if I were to use some white leads.

The straight zinc coat should have an "eggshell gloss" for the reason that, if it were perfectly flat such as the under paint coatings should be, it would absorb and draw the liquid properties from the enamel coat, leaving a surface of questionable uniformity.

The different coats of paint from the shellac up should be tinted as required for the finish, for by so doing you get a solidity of tint that you otherwise would not obtain. For a perfect white job, we oftentimes draw the lead; that is, we break up the lead in turpentine to a thin consistency, permitting it to stand 24 hours, then pour the surface liquid off; and you have remaining lead practically free from oil. With the percentage of zinc oxide specified, and with the use of a good white enamel varnish, or, what is still better, a portion of the enamel as a binder reduced with pure turpentine to a working consistency, you have a ground work for enameling that will be satisfactory in every respect.

NOTE 10.—This specification, if faithfully carried out, will produce splendid results. For high class work, cherry, birch, or plain maple should be used; good results can be secured on white pine or poplar.

Varnishing and Finishing of Hardwoods

Medium.—Sandpaper and remove all surface defects. Stain if desired. Fill with best paste filler, colored if necessary, thoroughly cleaning surface and moldings. Shellac one coat, and varnish two coats of a good varnish suitable for this purpose. After the shellac coat, close up all nail-holes and other imperfections with lead putty, colored as required, all surplus putty to be carefully wiped off. Sandpaper between each coat. Care must be taken during varnishing to keep the premises as free from dust as possible. (See Note 11.)

First-Class.—Sandpaper and remove all surface defects. Stain if required. Fill with best paste filler, colored if necessary. Thoroughly clean all surfaces and moldings. Shellac one coat pure grain alcohol shellac, and varnish four coats of a first-class varnish designed for this class of work. Rub all varnish surfaces true and even, with oil and pumice stone, to a dull satin finish. Thoroughly clean all oil and pumice stone from surface. Each coat must be thoroughly dry and sandpapered before the application of another. Care must be taken during varnishing, to keep premises as free from dust as possible. (See Note 12.)

NOTE 11.—If the location of the finish justifies additional expense and a flat surface is desired, specify that the last coat of varnish be lightly rubbed with oil and pumice stone to a uniform dull finish, thoroughly cleansing surface from all oil and pumice stone. In servants' portions of residences, this is not justifiable.

This specification pertains to all open-grained woods such as oak, ash, chestnut, black walnut, etc. If cherry, birch, maple, and such woods are used, frequently the filling with paste filler is eliminated, the shellac coating meeting requirements. In my own operations, I invariably use the filler as specified, but quite thin in body, carefully wiping off filler from surface. For birch stained in imitation of mahogany, I always omit the filler, shellacking direct on the stain, as frequently chemical action takes places when oil is brought in direct contact with mahogany stain used on birch.

NOTE 12.—This specification applies to the finishing of red or white mahogany, cherry, birch, walnut, rosewood, etc.

Frequently, in finishing mahogany or other woods stained with a water stain in imitation of mahogany or otherwise, after lightly sandpapering the stain, I apply a light coat of shellac directly on the stain, sandpaper lightly, then proceed with the filler and varnish as specified. White shellac should never be usd on dark mahogany or mahogany stained, as it will in time bleach out white, showing a milky film under the varnish. I also frequently omit both the shellac and filler, applying directly to the stain a coat of linseed oil reduced one half with turpentine containing a little dryer. After this has remained on for some time, wipe off carefully any oil that may remain on the surface; allow that which the wood has absorbed to get perfectly dry; then proceed with the varnishing as specified. In this latter case, four coats of varnish should be applied.

For white or bird's eye-maple, holly, satinwood, etc., eliminate the filler and stain, specify two coats of pure grain alcohol white shellac and three coats of an extra pale varnish designed for this class of work, rubbing and finishing as specified. In bringing oil into contact with these and similar woods, it has a tendency to darken, whereas the purpose is to keep them as light and natural as possible.

For Italian or French walnut, circassian walnut, and similar woods, where it is so important that the natural colors and shading be preserved, eliminate the filler, and apply as above two coats of pure grain alcohol white shellac and three coats of a light varnish, rubbing and finishing as spcified.

Fine carved work should never be varnished and rubbed as specified. Specify stain if necessary to conform with balance of wood; apply one light coat of shellac and two thin coats of wax rubbed to a hard surface with stiff bristle brush. One medium or light coat of a good flat varnish in place of wax, will answer very nicely. The filler with the several coats of varnish will aid in filling up and rounding the sharp edges and clean cutting so desirable in good carvings.

Staining and Waxing of Hardwoods

Medium.—Stain all work with an approved stain, color to be selected. Do necessary sandpapering, after which apply one coat of paste filler, colored to conform with stain. Thoroughly clean all surfaces, and apply one medium coat of shellac. Sandpaper lightly, and apply one good coat of an approved finishing wax, permitting it to stand until semi-hard; then to be thoroughly rubbed and polished to a hard surface. (See Note 13.)

First-Class.—Coat all surfaces (specify location) with one medium coat of clean water (this for oak only). When thoroughly dry, sandpaper to a perfectly smooth finish; after which stain uniformly and in

best manner with an approved water stain, color to be selected. Sandpaper lightly, and fill with paste filler, colored to conform with stain. Apply one coat of pure grain alcohol shellac; sandpaper lightly; after which apply two coats of an approved finishing wax, giving three days between coats. Permit each coat to become semi-hard; then to be thoroughly rubbed and polished to a hard surface. (See Note 14.)

NOTE 13.—This specification will apply to oak, ash, chestnut, mahogany, cherry, etc. If a finish with open wood pores is desired, eliminate the filling, but add one additional coat of wax.

NOTE 14.—This specification applies to oak, ash, chestnut, red and white mahogany, cherry, black walnut, etc., and calls for splendid results. A water stain is mentioned, it being the best and most satisfactory in showing up to advantage the general beauty of the natural shadings and figure of the woods. In staining, it should be emphasized that it does not mean a covering up, but rather the bringing out. In oil stains, the coloring matter is largely composed of pigments of a different character; and, as a rule, they are permanent; but they have a strong tendency to cover up. Spirit stains are hard to apply, and the results unsatisfactory, the coloring matter very often being fugitive. Where it is possible to attain the color requirements by the use of a water stain—and their number is legion—I would recommend it above all other. All water stains raise the grain of the wood more or less; spirit stains, very little; and oil stains, practically none. In connection with the use of water stain, I specify an application of clear water to the oak wood directly (in my practice I find no harm to a good job of cabinet work accruing from its use), so that the surface particles may be raised; and then cut off with sandpaper, so that the application of the water stain has no tendency to farther raise the grain. When the water coating is not used, and the water stain is applied directly, it requires so much sandpapering to recover again a smooth surface that much of the stain and its effects are removed by the sandpapering. The water coating is very frequently omitted on less important work. When oil and spirit stains are used, the water coat should be omitted for other than oak wood.

Very frequently, to get desired results, I apply a light coat of shellac directly on top of stain, after which I proceed with the filling as specified. I also frequently eliminate the shellac coating from on top of filler, applying wax directly on filler. The results desired must regulate the procedure.

When an open-grain or pore effect is desired, omit the filler, but add one additional light coat of shellac. It is very essential in this class of work that the shellac be applied thin and even, showing no laps or brush marks. If a perfectly flat or dead finish is required, omit both filler and shellac coatings, waxing as specified directly on the stain, although I would recommend the one coat of shellac. If the natural colors of the woods are to be retained, omit the staining, and proceed as specified and observing above notes.

For white and bird's-eye maple, satinwood, holly, French, Italian, and Circassian walnut, or any other similar woods, when required to be finished showing their natural colors, eliminate the water coat, stain, and filler; specify two thin coats of pure grain alcohol white shellac evenly applied directly on the wood, without showing laps or brush marks, sandpapering thoroughly each coat; then proceed with waxing as specified. When well done, this will give splendid results. Frequently mahogany and other woods than those specified above are finished after this manner. It is not unusual in procuring results to

eliminate the shellac coatings, waxing as specified directly on the raw wood. When stain is necessary, apply wax directly on same.

Often pleasing results can be obtained by using a first-class dead or flat varnish. For instance, if a perfectly dead finish is required on open-pore surfaces, after applying the stain, sandpaper and apply one thin coat of shellac; sandpaper lightly and apply one coat of a good flat or dead varnish; eliminate the waxing. To get a still flatter effect, eliminate the shellac also. This process is not recommended for durability, simply for its effect, and should be used only on open-pore woods such as oak, where the broken effect of the wood surface destroys the varnish coating effect. In this, window sash and sills should be protected with a coat of good body varnish; when dry, the gloss can be removed by rubbing.

Finishing Pine Floors

Thoroughly cleanse and remove all surface imperfections; shellac one coat, and varnish two coats of a good varnish designed for this purpose. Each coat must be thoroughly dry before the application of another. All necessary care must be taken to protect this work from damage. (See Note 15.)

NOTE 15.—This specification applies to white and yellow pine, also to maple. If this class of flooring is required to be stained, specify, instead of the shellac, floors to receive one coat consisting of 25 per cent linseed oil and 75 per cent turpentine; sandpaper and close up all imperfections. Apply one coat of stain consisting of 40 per cent linseed oil and 60 per cent turpentine, evenly brushed into the wood, color to be selected. Follow this with varnish as specified.

The so-called liquid fillers—that is, prepared fillers sometimes used to coat over the surface and permitted to remain there without rubbing off—should never be used, for the reason that they do not dry thoroughly throughout. Many of them also have a tendency to discolor the wood, especially when they begin to bleach out by reason of age, etc.

The object in going over this work with a very thin coating of oil and turpentine is, that, if you were to apply the stain directly to the wood, the result would be a clouded or mottled surface, owing to the natural characteristics of these different woods to absorb more in one spot or place than in another. Very little if any stain should be left on the surface. It should be absorbed uniformly by the wood, and be thoroughly dry before the application of the varnish coatings.

Where a dull finish is required, specify to be rubbed lightly with oil and pumice stone to a dull finish. A dull or flat varnish should never be used on floors.

Varnish Finish for Hardwood Floors

Thoroughly cleanse and remove all surface imperfections. Fill all woodwork with a good paste filler, cleaning thoroughly from surface. Stain if required. Shellac one coat, and varnish two coats of best varnish designed for floor use. Each coat must be thoroughly dry before the application of another. Care must be taken to protect floors from damage. (See Note 16.)

NOTE 16.—Very frequently the color desired for these floors can be obtained by adding necessary coloring matter to the filler. The color of the shellac (white or orange) should be determined by the color required.

If a flat finish is desired, specify to be rubbed with oil and pumice stone to an even, dull surface. A dull rubbed surface does not show surface scratches or abrasions as readily as a bright varnish gloss. Under no consideration use a flat or dead varnish to procure this result.

For first-class results you may eliminate the shellac coating and substitute one additional coat of varnish. It is very essential for best results that each coat be thoroughly dry before the application of another.

This style of finish is suitable for residences; but proper care must be exercised that it be not abused, for at best a varnished floor surface, from its very nature, is more or less fragile.

Wax Finishing of Hardwood Floors

Thoroughly cleanse and remove all surface imperfections. Fill all wood surface with one coat of best paste filler, thoroughly cleansing same when semi-dry, from surface. Stain if required. Apply one thin, even coat of pure grain alcohol shellac. Sandpaper lightly without showing laps, after which apply two coats of best prepared floor wax, giving two or three days between coats. Each coat must be thoroughly rubbed to a hard, dry surface. Care must be taken to protect floors from damage. (See Note 17.)

NOTE 17.—This specification applies to practically all kinds of flooring woods, and produces splendid results as a wax finish, being easily cared for by the housekeeper simply going over the surface lightly with turpentine, removing any surface dirt or imperfections, after which repolish with one coat of wax as specified. Especial care of the floor should be observed in front of the different doorways, as that portion receives the greatest amount of wear.

The whole secret of the success in obtaining a thoroughly practical waxed floor finish, is the recognition of the necessity of using a known good floor wax. Then thoroughly harden each coat with the friction caused by good, honest, hard rubbing.

This manner of finishing as specified, while it produces the best-appearing wax-finished floor has that which oftentimes is an objection, it being quite slippery. To remove in a large measure this objection, eliminate the coat of shellac from the specifications.

For dancing or ballroom floors, I would apply the two coats of wax directly to the floor. Of necessity, the wax must be good and the rubbing hard, allowing two days between coats.

CHAPTER XI

WOOD BLOCK PAVING

The round, untreated white cedar block was very largely used for paving in Northern cities many years ago, but it developed so many defects that wood paving came very much into disrepute. Within recent years, the introduction of sawed, rectangular creosoted blocks has given such excellent results that they have become a popular pavement throughout the United States, and especially where traffic is heavy or where a clean and comparatively noiseless pavement is desired. A well-creosoted block does not decay; and, if set upon a solid concrete foondation, the wear even under the heaviest traffic is very little, because the ends of fibers which are exposed simply mat down and do not shatter as do stone or brick. It is estimated that there are more than 30 million square yards of streets paved with wooden blocks in the United States, and the total increases yearly. The wood most largely used, because of its general availability, is longleaf pine; but Norway pine, Douglas fir and tamarack have also been used for some time with good results, and there is a disposition on the part of paving engineers to experiment with other woods. So, doubtless, the list will be much extended.

ESSENTIALS FOR A GOOD PAVEMENT

The essentials for a wood block pavement to withstand heavy traffic are well set forth by Walter Buehler, consulting engineer, in an address which follows:

> The blocks are manufactured in three sizes—3 inches, 3½ inches, and 4 inches deep. They vary in length from 5 inches to 10 inches, and in width from 3 inches to 4 inches. A few patented blocks are on the market, but the amount used is so small compared with the total

output that they are relatively of small importance. The depth of blocks to be used is dependent on traffic conditions. The width should be either greater or less than the depth, in order to assure blocks being laid with grain vertical. The length is somewhat dependent upon the depth. Three-inch blocks should have a maximum length not exceeding 8 inches; 4-inch blocks may have a maximum length of 10 inches. We sometimes see the statement that 4-inch blocks should be used on the streets of heavy traffic. This may be very misleading, for every resident of a small city believes that the main street is a street of heavy traffic naturally as compared with other streets in the same city. Few cities in the country require 4-inch blocks on their main streets, I believe a better way to classify for depth of blocks is as follows: Three-inch blocks on all resident streets of all cities; 3½-inch blocks on business streets of all cities under 150,000 population; 4-inch blocks on all business streets of cities over 150,000, with 3½-inch blocks on semi-business streets.

Much has been said and written as to the proper quantity of oil to be used. There are two principal considerations—first, quantity necessary to prevent decay; second, quantity necessary to prevent absorption of water and thereby help control expansion. Two and one-half gallons of oil per tie in the treatment of a railroad tie has been found to be ample to prevent decay. This is about 10 pounds of oil per cubic foot of timber. Therefore, taking into consideration the better conditions under which a paving block is laid, better drainage, etc., it should require less oil to preserve it than to preserve a railroad tie. For example: In my introduction I mentioned the blocks in Indianapolis, which had absorbed only six pounds per cubic foot, but are, after twenty years of service, perfectly preserved.

The second consideration—that is, the amount of oil necessary to prevent absorption of water—presents a different problem. Theoretically, we would assume that the greater quantity of oil used the less space for water, therefore the more waterproof. This assumption would be correct provided the cell spaces in the wood had anything to do with the expansion and contraction of the wood. It is a well known fact of timber physics that if the water is evaporated from a saturated stick, no change in size takes place until all of the water is out of the cell structure and begins to come out of the wood fibre itself. That is, as expressed scientifically, the point of fibre saturation is reached; therefore, a large quantity of oil in the cell structure does no especial good, but, on the contrary, acts as a reserve supply to prolong the period of bleeding. It is also a fact, I believe, that the preservative does not penetrate the fibre, but only the cell structure. Therefore, the value of the preservative relative to expansion and contraction is dependent upon its ability to penetrate the cell structure of the wood and paint the fibre structure with a layer of oil which will either keep the water in the fibre and the block expanded to its normal size, or keep the water out of the fibre of a thoroughly seasoned block.

As a paving block has six sides, on all of which the fibres are exposed, a certain amount of surface evaporation or absorption takes place. This accounts for the trouble with blocks treated with twenty pounds of heavy oil which expand with the first rain storm after they have been laid, when the blocks have been allowed to lie along the street for a long period before laying, or where thoroughly air-seasoned timber was used in the manufacture of the blocks. The quantity of oil alone will not prevent contraction or expansion. Other factors must be taken into consideration—that is, methods of treating and laying, both of which I will take up in detail. A sufficient quantity of oil should be used to thoroughly treat the blocks, the quantity varying with the quality. That is, I firmly believe that an average of sixteen pounds of an oil with a gravity of 1.06 to 1.08 is enough, and that an average of twelve pounds of an oil with a gravity of 1.08 to 1.12 is sufficient.

No other one feature of the creosote block pavement has been so much discussed as the quality of the oil to be used. In the early days very light gravity oils were used. These early pavements caused considerable trouble due to expansion and contraction. The quality and quantity of oil was blamed for this trouble, and each year found the manufacture advocating higher and higher gravity oils, and greater and greater quantities. This reached its climax in about 1913, when the standard specifications adopted by the Association for Standardizing Paving Specifications called for an oil of not less than 1.14 gravity at sixty-eight degrees Fahrenheit, and sixteen to twenty-two pounds of oil per cubic foot. In order to obtain this high gravity oil, it was found necessary by a good many manufacturers to use mixtures of distilled oil and tar; the tars used were either filtered coal gas tars or refined oil or coke oven tars. We soon began to have trouble, due to bleeding of the block pavements, and in addition the expansion trouble was not entirely cured. As a natural consequence a reaction took place, and, as is generally the case, the pendulum swung to the other extreme. We now began to hear of very light oil specifications; pure distilled oil specifications; restrictions as to oil tar, or other tar mixtures, etc. During all this period increasing amounts of creosote block pavements were being laid and it was becoming more and more popular. It is my personal opinion that within certain limits it makes very little difference what the quality of the oil is, provided that you have a staple oil and the blocks in proper condition for treatment, thoroughly penetrated with it, and then laid properly under the right conditions and a reasonable amount of attention given the finished pavement during its life. Entirely too much stress is being laid on character and quantity of oil to be used.

Proper methods of treatment are now most generally understood. The important points to consider are: Timber for treatment should not be too well seasoned; the oil should be forced in under slowly increasing pressure to assure a good and uniform penetration. All re-

sponsible timber preserving companies can be relied upon to treat the blocks properly.

We now come to a very important step in the making of a good creosote block roadway—that is, the proper construction methods to be used. The first consideration is that all block pavements should be laid on a concrete base. The thickness of this base is dependent entirely upon the character of the sub-soil and the weight of the traffic. Under average conditions throughout the United States five inches of concrete are sufficient. The concrete should be put in sufficiently wet to assure a smooth surface laid to proper grade and crown. The smoother the surface, the smaller amount of cushion necessary. The sole object of any cushion is to equalize the irregularities of the concrete and the under-surface of the pavement laid, and since creosoted blocks are manufactured with true plane surfaces the concrete surface need only be taken into account. Several materials are advocated for the construction of the cushion—sand, grout, and a painting of bitumen. A thin cement grout is now advocated as the standard. If the cushion is of sand, only enough should be used to give a true laying surface. In making the grout, a mixture of one part cement to four parts of sand, moistened sufficiently to mix and spread freely, is best. If the blocks are rolled and then sprinkled, enough water will get to the cushion in this way to assure the setting of the grout.

It is very important that before blocks are laid they be in proper condition. If blocks have been manufactured from seasoned material, or have been allowed to lay exposed along the line of the work, they should be thoroughly sprinkled before laying. Blocks may be laid at right angles with the center line of the roadway, or at an angle of twenty-two or forty-five degrees therewith. Not more than one row of blocks should be laid with their length parallel to the curbing, and an expansion joint of not less than one inch should be provided between this row and the curb. Under no consideration should transverse expansion joints be used. They are of no value and tend only toward unsightliness. Blocks should not be driven tight, but laid naturally; a slight tap against a liner may be used about every fifth course to keep the joint line straight. After the blocks have been laid they should be thoroughly rolled and at this time the last inspection should be made; all imperfectly sawed or unsound blocks should be replaced with good blocks and the whole surface given a finishing rolling.

The filler should then be put in. It should be unnecessary to state that the surface of the pavement before rolling or filling should be swept perfectly clean. The filler may be sand, pitch or asphalt. Sand filler must be used with caution. I would advocate its use only on streets of very heavy and continuous traffic, and only then when it can be thoroughly dried before using. Pitch or asphalt are the safest fillers. The precautions to be taken are to have the surface fairly dry and the filler sufficiently hot to flow freely. After filler has been put in a top dressing of sharp sand should follow. If a good sharp sand

or small flint gravel is used, and allowed to remain on the pavement for a sufficient length of time, the traffic will grind it into the surface of the blocks, assuring a surface that will not be slippery, and also making it more waterproof. This top dressing is generally removed too soon; wind storms blowing it about and making it a nuisance is gen-

Fig. 51.—Cross-Section of Creosoted Stick of Seasoned Red Oak. Treated by Open-Tank Method. Darkened Portions Show Penetration of Creosote.

WOOD PRESERVATION

erally the reason for its removal. This can be easily overcome by keeping the sand sprinkled. In fact, this should be done in order to hold the sand uniformly over the surface of the pavement. On the seventy miles of pavement in the city of Minneapolis, where they are never troubled with bleeding or slipperiness, the sand dressing is allowed to remain on all blocks laid in one season until the following season. There is a point I should have mentioned before: We sometimes hear the complaint that the creosote block pavement is exces-

sively slippery. Investigation has shown that in a great many cases the slipperiness was due to too much crown. It is very important that any pavement be sufficiently crowned to carry off the water rapidly, but care should be taken that this is not carried to excess.

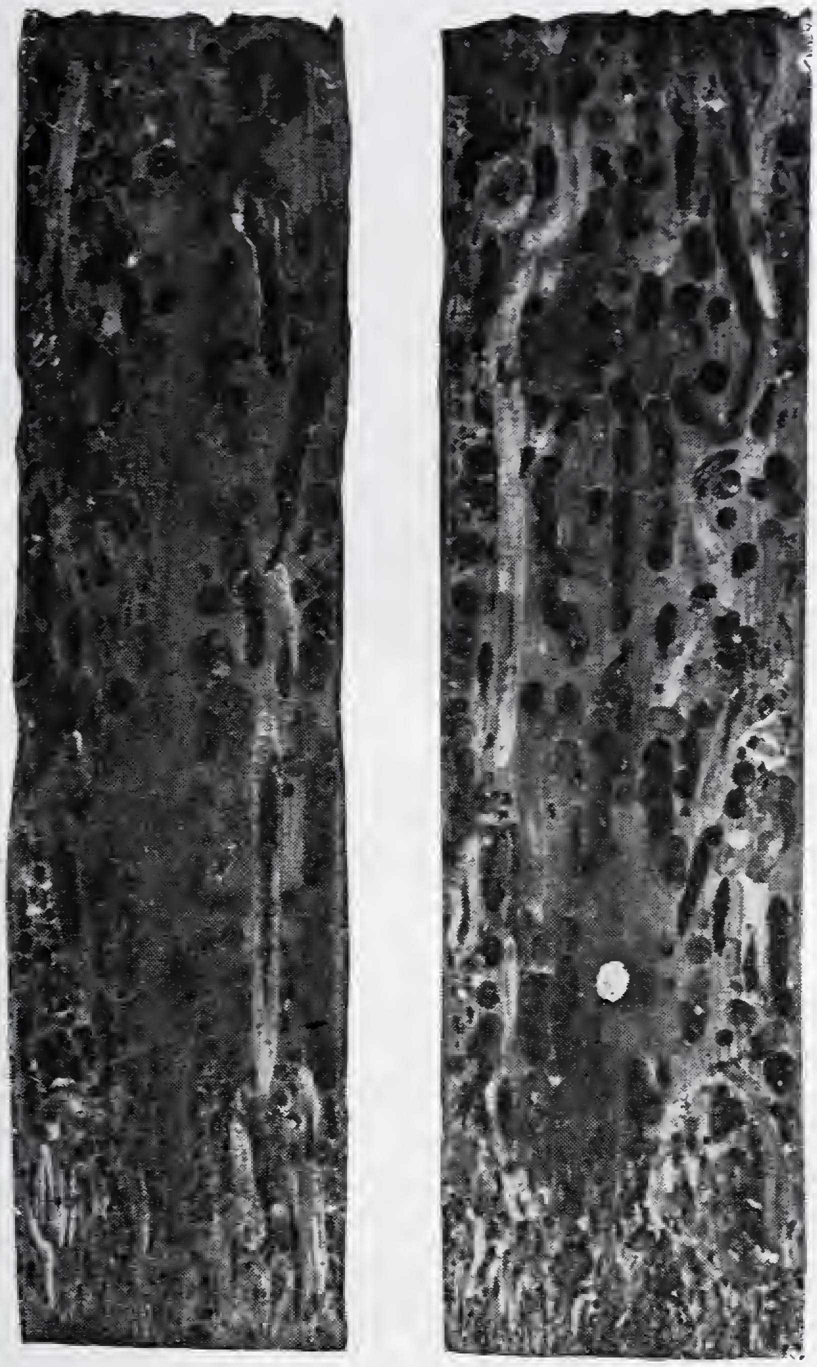


Fig. 52.—Untreated Piling Destroyed by Teredo in Fifteen Months in San Francisco Bay, Calif.

Forest Service Experiment. A Thorough Impregnation with Creosote Would Have Protected the Piling for Many Years.

WOOD PRESERVATION

Just a word about streets that have street railway tracks: It is well understood that track construction presents the most difficult of paving problems. Unless the whole track construction is of rigid character, I would not advocate the use of any permanent surface. If the construction is sufficiently rigid, there is no better surfacing material than the creosote wood block. I would, however, advocate the use of a

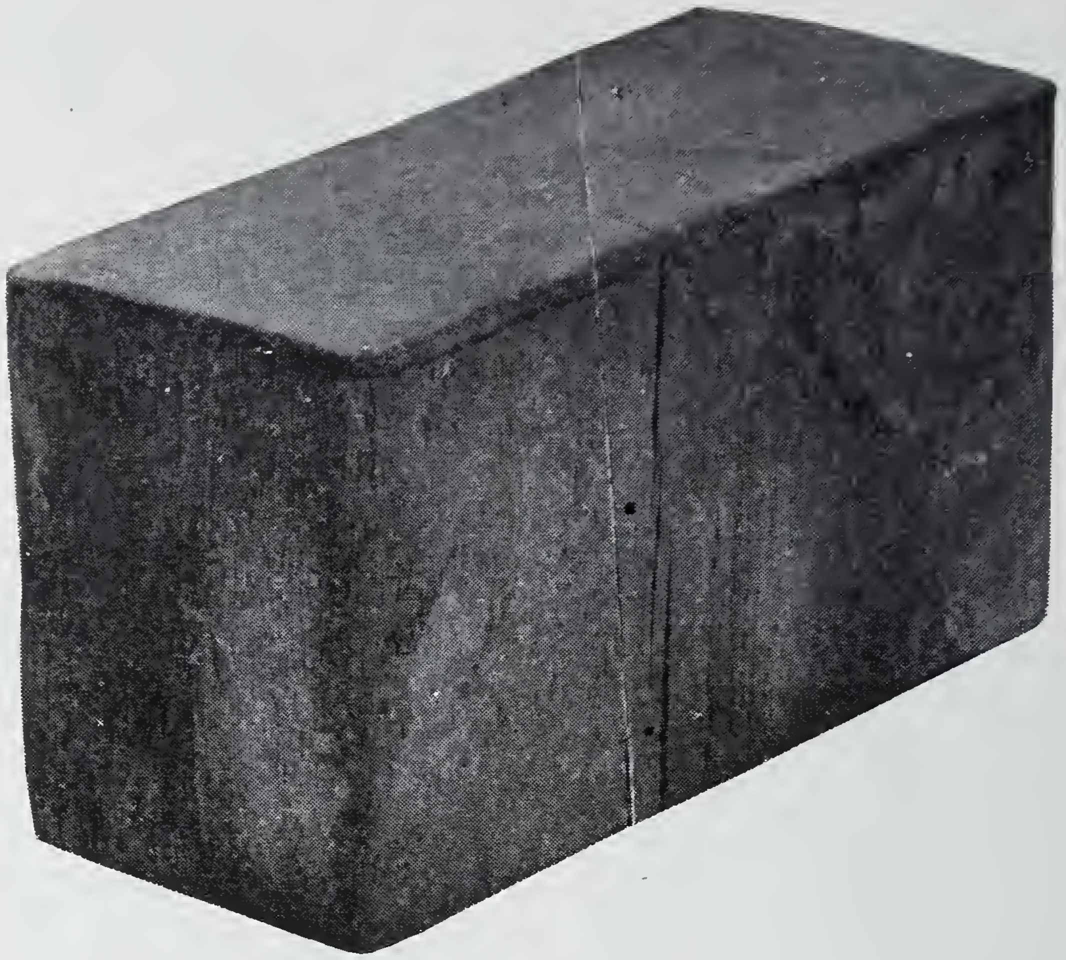


Fig. 53.—Creosoted Block of Longleaf Pine after Five Years' Service in Congress Street Pavement, Chicago.

WOOD BLOCK PAVING

Fig. 54.—Laying Creosoted Wood Block Pavement in Chicago.

WOOD BLOCK PAVING

grout cushion, for between the tracks, and one foot outside; with the blocks laid about one-quarter inch above the rail at the rail, falling to grade in the first foot from the rail. The object of this is to carry the water away from the rail quickly. This prevents it from getting in between the rail and the blocks.

Creosoted wood block pavement properly laid is without question the most durable, serviceable and comfortable pavement in existence. Any one riding over the block streets in New York, Chicago, Minneapolis, or any one of a hundred other cities, cannot deny this.

Its durability, its effectiveness, under heavy traffic, needs no further demonstration than the streets in lower Manhattan or the loop district in Chicago.

Its comfort and desirability are amply demonstrated by the miles of beautiful residence streets in such cities as Detroit, Minneapolis, and hundreds of others. Minneapolis alone has over seventy miles of block streets, some of these fourteen years old, and this year it is laying over 375,000 square yards. Detroit, with many miles of block pavement and years of experience, is laying over 200,000 square yards this year. When the public has used a great quantity of a material over a long period of years and continue to demand it, that material has surely stood the acid test.

Specifications for Wood Block Paving

The American Wood Preservers' Association adopted the following specifications for creosoted wood block paving at the annual meeting of the organization in 1923:

STANDARD SPECIFICATIONS FOR CREOSOTED WOOD BLOCK STREET PAVING

Kind.—The wood from which the blocks are to be manufactured shall be southern yellow pine, Douglas fir, tamarack, Norway pine, or hemlock. Only one kind of wood shall be used in any one contract.

Quality.—The blocks must be sound and well manufactured, square butted, square edged, free from unsound, loose or hollow knots, knot holes, worm holes, and other defects such as shakes, checks, etc., that would be detrimental to the blocks.

In southern yellow pine or Douglas fir the number of annual rings in the one inch, which begins 2 inches from the pith of the block, shall not be less than six, measured radially; provided, however, that blocks containing between 5 and 6 rings in the inch shall be accepted if they contain 33½ per cent or more of summerwood. In case the block does not contain the pith, the one inch to be used shall begin one inch away from the ring which is nearest to the heart of the block. The

blocks in each charge shall contain an average of at least 70 per cent of heartwood. No one block will be accepted that contains less than 50 per cent of heartwood.

Size.—The blocks may vary in length from 5 to 10 inches, but the maximum length shall not exceed two and one-half times the depth. They may be from 2¾ to 4 inches in width, but in any one city block all of them shall be of uniform width. A variation of $^1/_{16}$ inch shall be allowed in the depth and ⅛ inch in the width of the blocks from that specified. In all cases the width shall be greater or less than the depth by at least ¼ inch. The depth of the blocks required may be from 2½ inches to 4 inches, according to the condition of the traffic.

Preservatives.—The preservatives to be used shall comply with those specified by the committee on preservatives for coal tar paving oil and coal tar distillate oil and shall be incorporated in full as a part of this specification.

In view of the fact that water gas tar oil is being used for paving block purposes the committee deems it advisable to suggest the following specifications for their guidance:

Refined Water-Gas Tar.—The preservative shall be refined water-gas tar and shall comply with the following requirements:

1. It shall contain not more than 3 per cent of water.
2. It shall contain not more than 2 per cent of matter insoluble in benzol and chloroform.
3. The specific gravity of the preservative at 38° compared with water at 15.5° C shall not be less than 1.110 nor more than 1.140.
4. The distillates, based on water-free oil, shall be within the following limits:
   Up to 210° C—not more than 5 per cent.
   Up to 235° C—not more than 15 per cent.
   Up to 315° C—not more than 40 per cent.
   Up to 355° C—not less than 25 per cent.
5. The specific gravity of the total distillate below 355° C shall be not less than 0.99, nor more than 1.02 at 38° compared with water at 15.5° C.
6. The foregoing tests shall be made in accordance with the standard methods of the American Wood-Preservers' Association.

Treatment—Southern Yellow Pine, Tamarack, Norway Pine and Hemlock.—The timber may be either air seasoned or green; seasoned timber and green timber shall not, however, be treated together in the same charge. The blocks shall be treated in an air-tight cylinder with the preservative hereinbefore specified. In all cases, whether thoroughly air-seasoned or green, they shall first be subjected to live steam at a temperature between 220° and 240° F, but in no case shall the steam pressure exceed 20 lbs. per square inch for not less than two hours

nor more than four hours, at the discretion of the treating-plant operator, after which they shall be subjected to a vacuum of not less than 20 inches held for at least one hour. While the vacuum is still on the preservative oil, heated to a temperature of between 180° and 220° F, shall be run in until the cylinder is completely filled, care being taken that no air is admitted. Pressure shall then be gradually applied not to exceed 50 lbs. at the end of the first hour nor 100 lbs. at the end of the second hour, and then maintained at not less than 100 lbs. nor more than 150 lbs. until the wood has absorbed the required amount of oil.

After this a supplemental vacuum shall be applied in which the maximum intensity reached shall be at least 20 inches and shall continue for a total period of not less than 30 minutes. If desired this vacuum may be followed by a short steaming period.

In any charge the blocks shall contain at least 16 lbs. of water-free oil per cubic foot of wood at the completion of the treatment. The blocks after treatment shall show satisfactory penetration of the preservative, and in all cases the oil must be diffused throughout the sapwood. To determine this at least 25 blocks shall be selected from various parts of each charge, sawn in half at right angles to the fibers through the center, and, if more than one of these blocks show untreated sapwood the charge shall be retreated. After re-treating the charge shall be again subjected to a similar inspection.

The surface of the blocks after treatment shall be free from deposits of objectionable substances, and all blocks that have been materially warped, checked or otherwise injured in the process of treating shall be rejected.

Treatment—Douglas Fir.—The timber may be either air-seasoned or green. Seasoned timber and green timber shall not, however, be treated together in the same charge. The blocks shall be treated in an air-tight cylinder with the preservative agreed upon. They shall be treated by the boiling process substantially as follows:

The charge shall be boiled in creosote at not to exceed 190° F under vacuum of at least 20 inches for 2 and not to exceed 6 hours, depending upon the degree of dryness of the timber. The minimum temperature shall be sufficient to vaporize the moisture under the existing vacuum. Pressure shall then be applied not to exceed a maximum of 125 lbs. until the preservative has been absorbed in an amount about 3 lbs. per cubic foot in excess of the specified quantity. The temperature of the surrounding creosote shall then be raised to and held at 225° F for one hour. The creosote is then to be exhausted from the retort, steam shut off from the coils and a quick vacuum of 20 to 25 inches applied for a period of 30 minutes to one hour.

In any charge the blocks shall contain at least 12 lbs. of water-free oil per cubic foot of wood at the completion of treatment. The blocks after treatment shall show the preservative well diffused throughout the wood and the sapwood shall be entirely and well treated. To

determine this at least 25 blocks shall be selected from various parts of each charge, and, if more than one of these blocks show untreated sapwood, the charge shall be re-treated. After re-treating the charge shall again be subjected to a similar inspection.

The surface of the blocks after treatment shall be free from heavy pitch or tar-like deposits, and all blocks that have been materially warped, checked or otherwise injured in the process of treating shall be rejected.

Handling Blocks After Treatment.—With the bituminous paint coat method of construction the blocks shall be allowed to dry out as much as possible after treatment and before laying in the pavement. With the mortar cushion method of construction the blocks shall preferably be laid in the street as soon as possible after being treated. If they cannot be laid immediately, provision shall be made to prevent them from drying out by stacking in close piles and covering them, and, if possible, sprinkling them thoroughly at intervals. The blocks shall be well sprinkled, under the direction of the purchaser, about two days before being laid.

Inspection.—All material herein specified and processes used in the manufacture of the blocks therefrom shall be subject to inspection, acceptance or rejection at the plant of the manufacture, which shall be equipped with all the necessary gauges, appliances, and facilities to enable the inspector to satisfy himself that the requirements of the specifications are fulfilled.

The purchaser shall have the further right to inspect the blocks after delivery upon the street for the purpose of rejecting any blocks that do not meet these specifications, except that the plant inspection shall be final with respect to the kind of wood rings per inch, oil, and treatment.

Foundation.—The foundation for the pavement shall be of concrete constructed in accordance with the specifications of the purchaser for concrete-pavement foundation.

(a) Bituminous Paint Coat Method.—The concrete shall be finished to a smooth, even surface, exactly the depth below the finished pavement, corresponding to the depth of the block used. It shall also correspond exactly to the contour of the finished pavement. This finish may be obtained by striking the concrete to the exact grade with a template at the time of the placing of the foundation or by applying a mortar finish to the concrete foundation before it has taken its initial set.

On the thoroughly cleaned and dried concrete base shall be spread a thin hot uniform coating of coal tar pitch, as specified under "bituminous filler," or other suitable waterproofing bitumen. It shall be heated to a temperature of not less than 250° F, and not more than 300° F, and spread smoothly while hot to a uniform thickness of not to exceed ⅛ inch.

On the hardened bituminous paint coat the blocks shall be carefully

set with the fiber of the wood vertical, in straight parallel courses, leaving a space next to the curb 1 inch in width for an expansion joint.

The blocks shall be driven together every four course to keep the rows straight, and to eliminate subsequent slippage. Nothing but whole blocks shall be used, except in starting a course or in such other cases as the purchaser may desire, and in no case shall the lap joint be less than 2 inches. Closures shall be carefully cut and trimmed by experienced men. The angle of the courses to the curb shall be fixed at the discretion of the purchaser. After the blocks have been placed they may be rolled by a tandem roller, weighing between 2½ and 5 tons.

(b) Mortar Cushion Method.—Upon the concrete foundation, which shall first be cleaned and dampened and which shall be finished to within ½ inch of the given grade, shall be spread a layer of thoroughly mixed dry mortar, not exceeding ¾ inch in thickness and consisting of one part Portland cement of the character provided for in the foundation and three parts sand. Only sufficient water shall be added to this mixture to insure a proper setting of the cement, the intention being to produce a granular mixture which may be raked to the desired grade. The mortar shall be spread in place on the foundation immediately in advance of the laying of the blocks. The mortar bed shall be raked to the approximate grade in uniform density and struck by templates to a surface parallel to the grade and contour of the finished pavement. The finished mortar bed shall have an average thickness of not over ¾ inch and shall in no place be over 1 inch in depth.

Upon the bed thus prepared, after lightly sprinkling it with water, the blocks shall be carefully set with the fiber of the wood vertical, in straight parallel courses, leaving a space next to the curb 1 inch in width for an expansion joint.

The blocks shall be laid by setting them hand-tight on the base or cushion. No joint shall be more than $^3/_{16}$ inch in width. They may be driven together every ten courses to keep the rows straight. Nothing but whole blocks shall be used, except in starting a course, or in such other cases as the purchaser may direct; and in no case shall the lap joint be less than 2 inches. Closures shall be carefully cut and trimmed by experienced men.

The angle of course to the curb shall be fixed at the discretion of the purchaser.

After the blocks are placed on the mortar bed they shall be rolled parallel and diagonally to the curb by a tandem roller weighing between 4 and 7 tons until the surface becomes smooth and is brought truly to the grade and contour of the finished pavement. The rolling shall be completed before the mortar bed has set. All mortar that has set before the blocks are in place and rolled shall be discarded and replaced by fresh mortar.

(c) Bituminous Mastic Cushion.—A bituminous mastic cushion may

be used in a similar manner to the cement mortar cushion, the mastic to consist of approximately 10 per cent suitable bituminous material, either coal tar or asphaltic oil, and 90 per cent clean, dry, screened sand. The mastic shall be thoroughly mixed and spread to the approximate grade in a uniform density and struck by template to a surface parallel to the contour of the finished pavement, this cushion shall be spread a day in advance of the placing of the blocks to allow the mastic to cure; the laying of the blocks shall then proceed the same as with the cement mortar cushion.

Expansion joints 1 inch wide shall be provided next to and along the curb-line, expansion joints being filled with bitumen as specified for filling the joints.

After the rolling and surfacing is completed, the joints between the blocks shall be filled with a bituminous filler, as hereinafter specified. This bituminous filler shall preferably be applied only when the temperature of the air is about 45° F.

The bitumen shall be heated to the highest possible temperature without burning or injuring its consistency and shall be flushed over the surface of the blocks, working it into the joints between the blocks by means of a hard-rubber edged squeegee. Care must be exercised so that no undue surplus of bitumen is left on the surface of the blocks.

After the filler has been thoroughly worked into the joints between the blocks, the surface of the pavement shall be completely covered to a depth of about ½ inch with coarse, clean, sharp sand or stone screenings which shall be permitted to remain under traffic for several weeks.

Filler Specifications.—Either coal-tar-pitch or asphalt fillers according to the following specifications shall be used:

Coal tar pitch—The pitch used as filler shall be obtained entirely from the distillation of coal-tar and shall comply with the following requirements:

A. Specific gravity at 77° F (25° C) shall not be less than 1.22 nor more than 1.34.

B. Free carbon shall not be less than 16 per cent nor more than 37 per cent.

C. Melting point shall not be less than 145° F nor higher than 155° F when determined by the half-inch cube method. (See Note 1.)

Note 1.—Melting point test for coal tar pitch—A clean shaped ½ inch cube of the pitch to be formed in a mold, placed on a hook of No. 12 copper wire and suspended in a 600 c. c. beaker so that the bottom of the pitch is 1 inch above the bottom of the beaker. (A sheet of paper placed on the bottom of the beaker and conveniently weighted will prevent pitch from sticking to the beaker when it drops off.) The pitch to remain 5 minutes in 400 c. c. of water at a temperature of 60° F (15.5° C) before heat is applied. Heat to be applied in such manner that the temperature of the water is raised 9° F (5° C) each minute. The temperature recorded by the therometer at the instant the pitch touches bottom of beaker to be considered the melting point.

D. When 100 grams of pitch are distilled to 670° (355° C) in an 8-oz. retort, specific gravity of the distillate shall not be less than 1.07 at 100° F (37.7° C).

Asphalt—The filler shall be an asphalt cement and shall comply with the following requirements:

1. It shall contain at least 98.0 per cent of bitumen soluble in carbon di-sulphide.
2. It shall have a penetration within the following limits:
   When tested at 32° F for 1 minute under 200 grams, 10 to 20.
   When tested at 77° F for 5 seconds under 100 grams, 30 to 50.
   When tested at 115° F for 5 seconds under 50 grams, 150 to 300.
3. It shall show a ductility of at least 30 centimeters when tested at 77° F.
4. When 50 grams are heated in an open tin to a temperature of 325° F for 5 hours, the loss shall not exceed 1 per cent, and the penetration at 77° F of the residue left after such heating must not be less than two-thirds of the penetration of the original asphalt cement before such heating when tested at 77° F.

As a substitute for the pitch filler specified in the bituminous paint coat construction the following special pitch filler may be used. The filler shall be made from the products obtained from the distillation of coal tar only, no admixtures of other materials will be permitted, and it shall comply with the following requirements and tests made as indicated:

1. The filler shall contain no water.
2. Its specific gravity at 15.5° C (60° F) shall be not less than 1.20 nor more than 1.23.
3. Distillation: When distilled as below required it shall show percentage distilled by volume as follows:
   From 0 to 1 per cent at 100° C (212° F)
   From 1 to 10 per cent at 170° C (338° F)
   From 20 to 40 per cent at 355° C (671° F)
4. The specific gravity of the distillate at 15.5° C (60° F) shall be from 0.950 to 1.03.
5. The melting point of the residue by the air-bath ½ inch cube method shall be from 117.8° C (244° F) to 126.7° C (260° F).

Open-Joint Construction.—When the blocks are laid on streets having grades of 3 per cent or over it is desirable that the blocks be spaced with open joints. This spacing may be secured by laying creosoted wood lath about $^5/_{16}$ inch thick between each course, or by other approved methods of spacing. The space between the blocks shall then be filled with a mastic filler, consisting of equal parts of stone screen-

ings and bitumen, as previously specified. The joints shall be filled about two-thirds full of the bituminous mastic filler specified, care being taken to leave as little as possible on the surface of the pavement. Stone screenings shall then be spread over the surface of the pavement and permitted to work into the top of the joints under traffic. It is essential to drive the blocks together every four rows to prevent tipping and slipping of the individual blocks.

Maintenance.—The pavement shall be inspected each summer and, whenever it shows signs of shrinkage or open joints, it shall be given a surface treatment of light tar oil or other suitable bitumen and sand. The bitumen used for this purpose shall be completely liquid at atmospheric temperatures and shall be applied during dry hot weather in quantities of about one-quarter to one-third gallon per square yard of pavement. Sand shall be then spread over the pavement to a depth of about ½ inch, several hours after the application of the bitumen, and permitted to remain for several weeks under traffic.

STANDARD SPECIFICATIONS FOR INTERIOR WOOD-BLOCK FLOORS

Kind.—The wood from which the blocks are to be manufactured shall be air-dry Southern yellow pine, Douglas fir, tamarack or Norway pine. The blocks must be sound and well manufactured, square butted, square edged, free from unsound, loose or hollow knots, knot holes, and other defects, such as shakes, checks, etc., that would be detrimental to the blocks.

In Southern yellow pine or Douglas fir the number of annual rings in the 1 inch which begins 2 inches from the pith of the block shall not be less than six, measured radially, provided, however, that blocks containing between five and six rings in this inch shall be accepted if they contain $33\frac{1}{3}$ per cent or more summerwood. In case the block does not contain the pith, the 1 inch to be used shall begin 1 inch away from the ring which is nearest to the heart of the block.

The blocks may vary from 5 to 8 inches in length, the maximum length not to exceed three times the depth; they may vary from 2¾ to 4 inches in width, but on any one floor all of them shall be of uniform width. A variation of $\frac{1}{16}$ inch shall be allowed in the depth, and ⅛ inch in the width of the blocks from that specified.

The preservatives to be used shall comply with those specified by the committee on preservatives for coal tar paving oil and coal tar distillate oil.

Blocks shall be treated in air-tight cylinders in accordance with any standard empty cell process adopted by the American Wood-Preservers' Association, leaving in the blocks at the end of the treatment not less than 6 lbs. of water-free creosote oil per cubic foot of wood. The gross absorption of oil injected during the process of treatment shall be sufficient to insure a thorough impregnation of the preservative.

The blocks after treatment shall show satisfactory penetration of the preservative, and in all cases the oil must be diffused throughout the sapwood.

The blocks shall be stored under cover upon arrival on the work and protected from the weather at all times before being laid. It is important to have the blocks as dry as possible at the time the floor is constructed. Wherever it is possible seasoning of blocks for a period of 30–60 days after treatment is highly recommended.

The sub-grade shall be thoroughly rolled, tamped, or otherwise prepared to prevent yielding after the concrete base and woodblock floor are placed.

The committee recommends the bituminous paint coat construction for general use.

Blocks must not be driven up tightly together when wet or humid conditions are encountered. Some provision for expansion must be provided in this case and the blocks shall be well sprinkled with water about two days before being laid. It is frequently advisable to use a heavier oil treatment for wet floors and to conform to the specifications prescribed for street paving.

Against the walls on all sides of the floor, as well as around all columns and other obstructions, a bituminous expansion joint 1 inch in width shall be formed by, first, laying a strip of that width and after removal, filling the space to within an inch of the top with the same bitumen used as a filler.

Blocks may be laid over worn out concrete floors or rough concrete slabs already constructed by the application of a cement mortar or bituminous mastic finish to the concrete to smooth and level up the base. The cement mortar shall be mixed in proportions of 1 part cement to 3 parts sharp sand, and shall be mixed wet and finished with a wooden float. The bituminous mastic shall consist of approximately 10 per cent coal tar or asphaltic oil and 90 per cent clean, dry, screened sand.

Blocks may be installed over a timber foundation whenever the foundation is rigid and solid. In that case the timber shall be surfaced so as to form an even bearing for the blocks or the depressions shall be leveled up with a bituminous mastic similar to that described above for bituminous mastic cushion. It shall then be covered with a two ply membrane of roofing felt cemented together and coated with hot bitumen. The laying of the blocks shall then proceed as outlined in the bituminous paint coat method on concrete base.

CHAPTER XII

HARDWOOD FLOORING

One of the most notable and useful developments of modern lumber manufacturing is the production of high-grade flooring of maple, beech, birch, oak, tupelo, yellow pine, Douglas fir, and other woods. This flooring is manufactured to exact standard sizes from selected, thoroughly seasoned stock, and is as carefully handled as is interior finish. In fact, a beautiful and durable hardwood floor is an important part of the inside finish of a building, now that carpets are being widely replaced by rugs.

Since hardwood flooring is manufactured from kiln-dried stock, is stored by the maker in dry sheds, and is shipped in closed cars so as to reduce the absorption of moisture, the user should make every effort to have the flooring carefully handled, correctly laid, and properly finished. Some of the points to bear in mind are to avoid unloading the flooring in damp weather; not to store it in open sheds or in newly plastered buildings; nor to lay it until the building is thoroughly dried out. When an under-floor is used, as is advisable with the thinner sizes, the hardwood flooring should be laid diagonally or across the sub-floor, and the latter should be dressed to an even surface.

The best practice indicates the use of steel cut nails for hardwood flooring. These nails are manufactured especially for this purpose. They should be driven at an angle of 45 degrees; and it is stated that better results are obtained if no nails are placed within six inches of the end of the flooring pieces.

Maple, beech, and birch are close-grained woods of similar structure which give equally good appearance and service for flooring, whether slash- or quarter-sawed. Red and white oak

floors are popular in both the plain and quartered forms, depending upon the figure desired; while quarter-sawed or edge-grain yellow pine and Douglas fir are very much better than slash-sawed floors of these woods. Strictly speaking, yellow pine and Douglas fir are soft-woods, but edge-grain flooring made from them gives such good service that it is widely used for the same purposes as hardwood flooring.

MAPLE, BEECH, AND BIRCH FLOORING*

The Maple Flooring Manufacturers Association has the following rules for maple, beech, and birch flooring:

Clear Grade

Clear.— $^{13}/_{16}$ inch and thicker, shall have one face practically free of all defects, but the question of color shall not be considered. Standard lengths in all widths in this grade shall be trimmed 2 to 16 feet; the proportion of lengths 2 to 3½ feet shall be what the stock will produce up to 20 per cent.

This grade combines appearance and durability and has a face free of defects that will materially mar the appearance of the finished floor or impair its durability. It will be noted that the standard of appearance is that of a finished floor, not the top of a piano. A practical application of this rule will admit an occasional small sound pin knot not over ⅛ inch in diameter, dark green or black spots or streaks not over ¼ inch wide and 3 inches long or its equivalent, birdseyes and small burls, a slightly torn grain or similar defect which can be readily removed by the ordinary method of smoothing the floor when it is laid, a slightly shallow place not over 12 inches long on under side of flooring if it does not extend to either end of the piece, an otherwise perfect tongue which is one-half short for 25 per cent of length of piece is admissible, but the face must be free of checks or shake and the wood must be live and sound.

No. 1 Grade

No. 1.—$^{13}/_{16}$ inch and thicker, will admit of tight, sound knots and slight imperfections in dressing, but must lay without waste. Standard lengths in all widths in this grade shall be trimmed 1½ to 16 feet; the proportion of lengths 1½ to 3½ feet shall be what the stock will produce up to 40 per cent.

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This grade is made for service rather than appearance. It admits of tight, sound knots, prominent discolorations, numerous dark green or black spots or streaks, slight checks not exceeding 3 inches in length and running parallel with and well inside of the edges of the strip, dark spots or streaks with slight checks in center, small rough spots which cannot be wholly removed by the ordinary method of smoothing the floor when it is laid, slightly torn edges, short tongue if sufficient to hold properly in the floor, shallow or waney back if piece has sufficient bearings of full thickness to support it in floor, and slight variation in angle of end matching. While these and similar features are admissible, sufficient attention is given to appearance to make this grade desirable and satisfactory for use in stores, school houses, and similar places where a waxed or varnished floor is not required.

Factory Grade

Factory.—$^{13}/_{16}$ inch and thicker, must be of such character as will lay and give a good serviceable floor, with some cutting. Standard lengths in all widths in this grade shall be trimmed 1 to 16 feet; the proportion of lengths 1 to 3½ feet shall be what the stock will produce up to 60 per cent.

This grade is suitable for factory, warehouse and kindred uses, and where a low-priced floor is wanted for wear, nothing better or cheaper can be obtained than the factory grade.

Special Grades

White Clear is special stock manufactured from white clear maple lumber from the outside of the log, winter-sawed, and end-piled in sheds to prevent staining, is almost ivory white, and is the finest grade of maple flooring it is possible to produce.

Red Clear Beech and **Red Clear Birch** are manufactured from all-red face stock, especially selected for color, and are free from all defects. The color is a rich, warm tint peculiar to no other wood.

The standard sizes for maple, beech, and birch flooring are indicated in Table 14.

TABLE 14

STANDARD SIZES FOR MAPLE, BEECH, AND BIRCH FLOORING

Standard Thickness	Faces	Grades
$\frac{13}{16}''$	1½″, 2″, 2¼″, 3¼″	Clear, No. 1, Factory
Special Thicknesses		
$1\frac{1}{16}''$, $1\frac{5}{16}''$, $1\frac{11}{16}''$,	2″, 2¼″, 3¼″	Clear, No. 1, Factory
⅜″, ½″, ⅝″	1½″, 2″, 2¼″	Clear and No. 1 only

⅝″ and thicker, all Faces, is measured ¾″ waste for matching.
½″ and thinner, all Faces, is measured ½″ waste for matching.

The association makes the following recommendation for the use of the different grades:

Clear, or first quality, is suitable for apartment buildings, churches, clubs, dancing floors, gymnasiums, hospitals, hotels, office buildings, public buildings, residences, roller-skating rinks, school houses, stores, and similar buildings.

No. 1, or second quality, is a common grade, and its relation to clear is similar to that between second and first grade of finish. It is just as serviceable as clear, and equally as desirable when there is no objection to the appearance; and it can be used in the same class of buildings as the clear grade at a material saving in the cost of construction.

Factory, or third grade, will give excellent satisfaction in factories, creameries, granaries, mills, warehouses, workshops, and in other buildings, at mines, on farms, etc. Where a low-priced floor is wanted for wear, nothing better or cheaper can be obtained than this grade.

Laying and Finishing Hardwood Floors

By permission of the Maple Flooring Manufacturers Association, the following directions for laying and finishing maple, beech, or birch floors are reproduced:

DIRECTIONS FOR LAYING FLOORING

For the under floor use sound softwood matched stock or the factory grade of maple, beech or birch flooring and lay it diagonally or at right angles to the proposed run of the top floor. Hardwood makes the best subfloor, but must be kept dry.

If the top floor is to be laid directly on the subfloor—or with only deadening felt between—nail all twisted, cupped or broken members of the subfloor securely in place, so that a substantial and even surface will be secured.

In some buildings the hardwood flooring is laid on furring strips. If that method is called for, the face of the strips must be lined up accurately.

Building Must Be Dry

Do not permit maple, beech or birch flooring to be delivered until the building, including the plaster, is thoroughly dry. Occasionally the

flooring is much dryer than the building and absorbs moisture which causes the strips to swell before they are laid. When heat is applied the moisture is driven off, the strips shrink, and cracks appear.

Dry flooring laid in a damp building will swell and cause cupping or buckling. The only remedy for a cupped floor is to scrape it to a true surface. It is almost impossible to drive a buckled floor back into place, the nails tending to support it in the position into which it was forced. The alternative is to take up the flooring and relay it.

Wait until the building is dry and have a perfect floor.

When to Begin Work

The proper time to lay maple, beech or birch flooring is when the building, including the plaster, is thoroughly dry and right after the interior trim has been installed and finished.

If work must be started before that time the floor should be primed as soon as possible after it is put down. When the primer is hard, cover the floor with sized building paper. The primer will keep out the dirt and also tends to prevent the absorption of moisture.

Dipping the flooring strips in raw linseed oil, heated as nearly as possible to the boiling point, will safeguard them effectively from moisture. Flooring so treated may subsequently be waxed or varnished.

Dipped flooring has been used with excellent results in reflooring buildings in use. Three or four days should be allowed to insure thorough absorption of the oil.

Laying the Floor

If the trim is in place line up the first course of stripes flush with the face of the mopboard which must not extend below the surface of the top floor. Do not, under any circumstances, drive the flooring tight against studding or walls. Nail the first course directly through that portion to be covered with the quarter round or base shoe.

Plan in advance to meet the situation where the floor continues into other rooms. Thresholds are little used now and the courses of flooring strips should run true from one end to the other, regardless of the number of rooms through which they pass.

Ordinarily the floor in the center of the room is covered with rugs. Select the choice strips for the sides and ends which form the exposed portions and which are always in view.

Use a block to drive the strips together or to drive them endwise. Do not batter the tongue, injure the matching or mar the surface.

Economy of End Matched Flooring

The flooring is furnished in mixed lengths, which facilitates rapid laying, as it enables the workmen to combine the lengths economically and avoids unnecessary waste in cutting. The shorter lengths are

particularly handy in this respect as they fit in readily and can be driven together quickly with a tap of the hammer.

When necessary to trim a piece of flooring to finish out a course, it is better to use a piece of sufficient length so that the part trimmed off may be used for starting a new course. This is an economy which will suggest itself to competent floor-layers.

Do not start to nail until the strip is in place. It is unwise to rely wholly or largely on the nails to draw the strips together.

Damage to tongue makes it difficult to enter the groove of the next piece.

The Proper Nails to Use

It is very essential that the proper nails be used in laying hard-

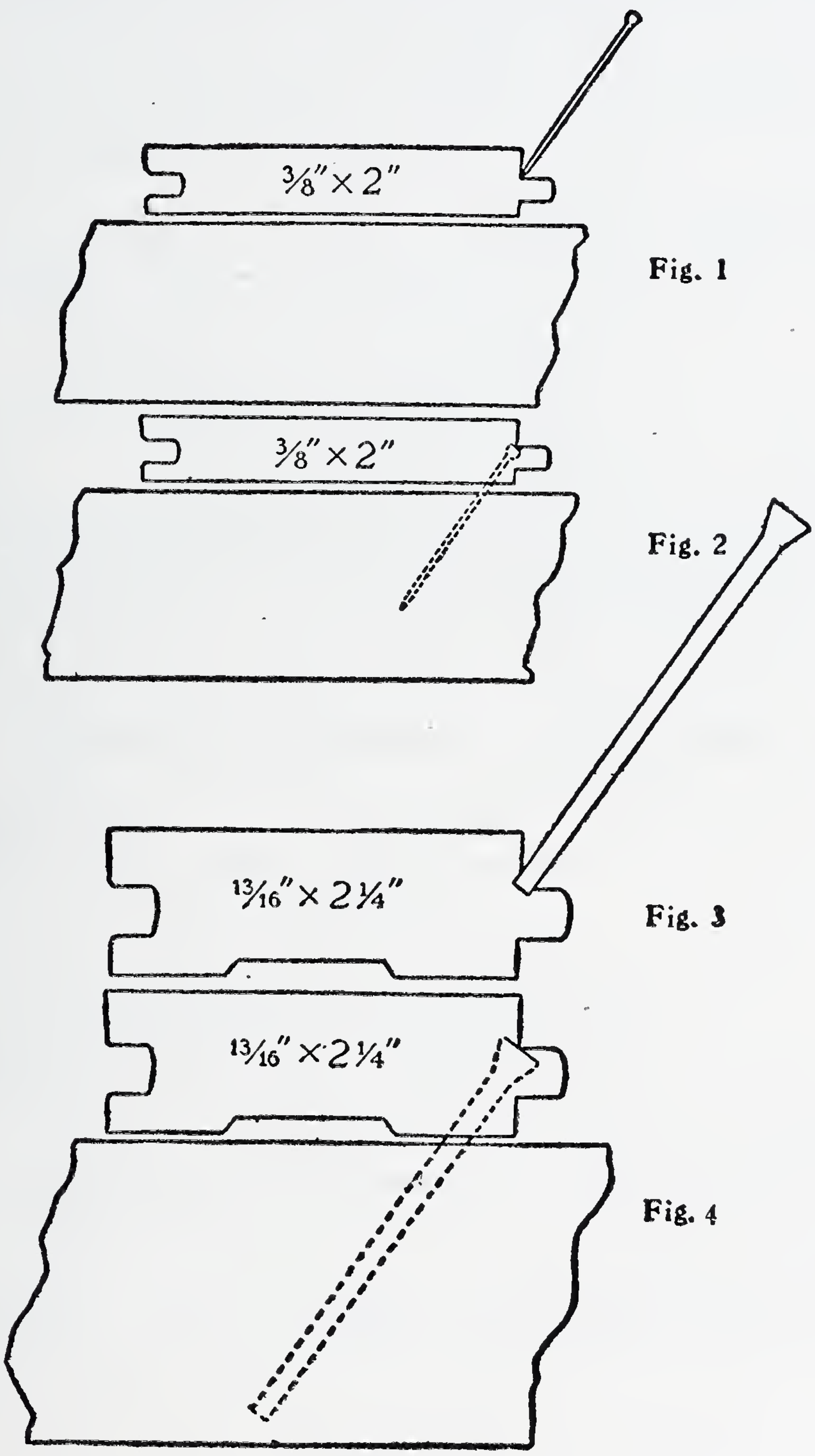

Fig. 55.—Nailing Hardwood Flooring.

wood flooring to prevent splitting the tongue and bruising the face. For the best results the following are recommended:

Threepenny finishing nails for $\frac{3}{8}$-inch thick, used 9 inches apart.

Eightpenny cut flooring nails for $^{13}/_{16}$-inch thick, used 16 inches apart.

Tenpenny cut flooring nails for $1^{1}/_{16}$-inch thick, used 16 inches apart.

The threepenny is a wire nail and on account of the small gauge and medium length is best adapted to thin flooring.

The eightpenny and tenpenny are steel-cut nails, manufactured especially for laying hardwood flooring and are being used by up-to-date contractors and floor-layers. These nails are the same thickness from point to head and have two smooth sides which are set parallel with the tongue, eliminating the strain from the narrow part of the tongue. They are wedged shape in width, which puts the entire strain lengthwise of the tongue. The rough edges give these nails drawing and holding qualities not contained in any other nail, and after being driven their entire length they remain in position, producing and maintaining a perfectly tight joint.

The nails should be driven at an angle of 45 to 55 degrees, and the first nail or two driven in the piece of flooring should be ''toe-nailed'' toward the preceding piece to which it joins.

Figure No. 1 shows the threepenny finishing nail in the position it should be held in starting, and figure No. 2 shows the same nail after being driven its entire length and set.

Figure No. 3 shows the eightpenny cut flooring nail in the position it should be held in starting, and figure No. 4 shows the same nail after being driven its entire length and set.

PROPER METHODS OF FINISHING HARDWOOD FLOORS

The finishing processes recommended by the Maple Flooring Manufacturers Association are the result of considerable investigation. It was found that each competent flooring contractor had a personal preference for his own method of finishing maple, beech, or birch—a natural result of the pride taken in the handling of these fine woods.

The problem was to standardize these various methods so that a generally accepted formula for finishing could be evolved for the benefit of home owner and contractor alike.

By following these suggested methods, any flooring contractor can finish hardwood flooring so that full surface and color values are realized.

Pleasing effects—complete color harmony—and durability of finish are certain when the good workman follows these simple directions.

Scraping

After the hardwood floor is laid, it should be scraped and sandpapered to a smooth surface. This scraping should be done with a

sheering cut lengthwise of the grain. Then sweep the floor clean and wipe carefully with a soft cloth until all dust is removed.

Wax Finishing Beech and Birch

Natural Finish: First, fill with wood alcohol and light colored umber mixed to the consistency of thick cream, and rub thoroughly into the wood. Never use benzine, which evaporates and may discolor. Wood alcohol, originally from the wood itself, penetrates hardwoods. Second, apply two coats of alcohol shellac and rub each coat well when dry. Third, apply one coat of linseed oil and pumice stone and rub well. Fourth, apply one coat of equal portions of wood alcohol and turpentine mixed and rub well. Fifth, apply three or four coats of light colored floor wax, rubbing each coat thoroughly before applying the next. If an even colored finish is desired put a little cherry stain in the filler.

Special White Finish for enameled bedrooms and bathrooms: First, fill with wood alcohol and best quality white lead and rub thoroughly into the wood. Second, treat same as above.

Wax Finishing Maple

Natural Finish—White Clear: First, fill with umber and best quality white lead thinned with wood alcohol mixed to the consistency of thick cream, and rub thoroughly into wood. Second, apply two coats of alcohol shellac and rub well. Third, apply one coat of linseed oil and pumice stone and rub well. Fourth, apply one coat of equal portions of wood alcohol and turpentine mixed and rub well. Fifth, apply three or four coats of light colored floor wax, rubbing each coat thoroughly before applying the next.

Clear: Finish same as White Clear, unless an even color is desired; then mix a little gray umber in the filler.

Staining Maple, Beech, and Birch

The most successful process for staining maple consists in using a filler of wood alcohol and best quality white lead stains going in with this filler. Rub thoroughly into the wood.

Follow this process for beech and birch, which take stains admirably, but a thin, transparent stain should be used that will color the wood without obliterating its character. Try out on small surface to see that you have gained the right color.

Applying Stains Direct to the Wood

Oil stains are recommended when a stain is to be applied direct to the wood. Oil stains do not set quickly and give the operator longer

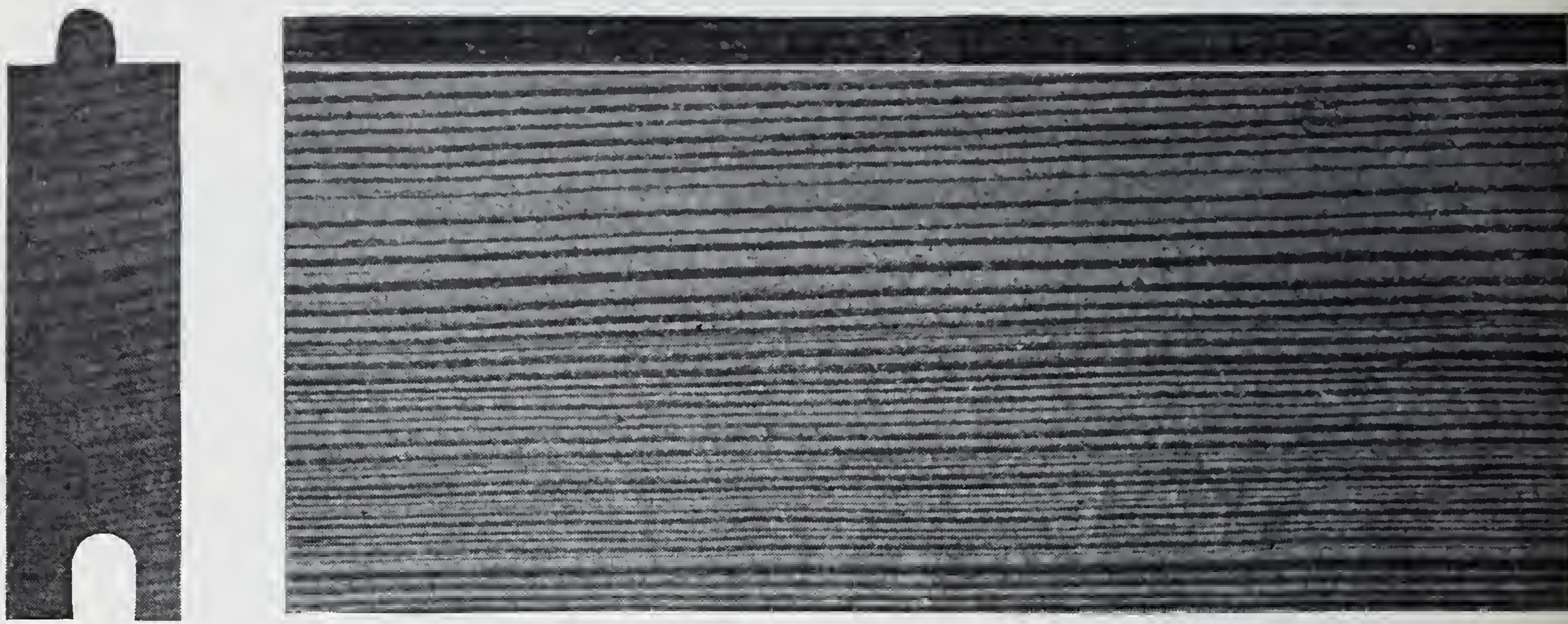

Fig. 56.—Edge-Grain Yellow Pine Flooring.

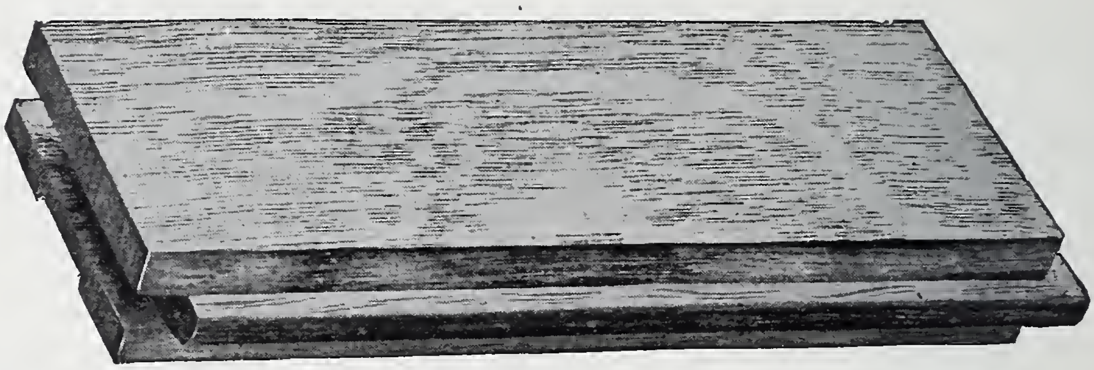

Fig. 57.—Quarter-Sawed, Tongued-and-Grooved, End-Matched Oak Flooring.

Fig. 58.—Plain-Sawed, Tongued-and-Grooved, End-Matched Oak Flooring.

TYPICAL KINDS OF FLOORING

time in which to work. The color should be worked into the wood and not allowed to remain on the surface. Rub off to an even tone before the stain hardens.

Varnished Floors

A satisfactory method of varnishing maple, beech, or birch floors is to thin the varnish by adding turpentine, the quantity to be added varying from 10 to 30 per cent, and applying the varnish thus prepared directly to the wood.

When dry and hard, sandpaper lightly with No. 00 sandpaper to remove the small air blisters; wipe clean and give a coat of full body varnish just as it comes from the can. A third coat should be given in the same way and rubbed down with pulverized pumice stone and rubbing oil. Then the floor should be wiped dry and clean, removing all the oil.

Varnish does not dry so well at night, with or without artificial light, as in the day time. Ventilation, temperature, and light are important.

Windows should be open to insure ventilation.

Important: Do not use liquid fillers or shellac under varnish. The floor must be dry and clean before a drop of finishing material is placed on it. Temperature should be between 70 and 80 degrees.

Portions of varnished floors subjected to excessive wear may be renewed if the work is undertaken before the wood is exposed and turns dark.

Such portions should be cleaned with white soap and water and a thin coat of varnish applied. This should be rubbed well, then coated with full body varnish and rubbed down to correspond with the remainder of the floor.

Finishing the Service Floor

It is a good investment to give the industrial—or service—floor a hot oil treatment when laid. The most efficient way is by dipping the flooring strips in raw linseed oil, heated as nearly as possible to the boiling point. This is generally done by the installation of a large tank on the grounds and any competent flooring contractor can do this. A good grade of linseed oil should be used. Three or four days should be allowed for thorough absorption of the oil. The usual treatment, however, consists in coating the floor, immediately after it has been laid, with raw linseed oil, the oil being heated as nearly as possible to the boiling point and applied with a mop while hot.

Commercial preparations for floors in public buildings, factories, office buildings, churches, stores, etc., are frequently used instead of this hot oil treatment.

There are several such preparations on the market which are easily applied to the newly laid floor and the Maple Flooring Manufacturers Association will furnish manufacturers names upon request.

A B C D

Fig. 59.—Torch Tests Showing Effect of Paint in Preventing Spread of Fire and Retarding Charring of Wood.

Effect at end of 1-minute test on untreated shingle (A) and painted shingle (B); 3-minute test, untreated (C), and painted (D).

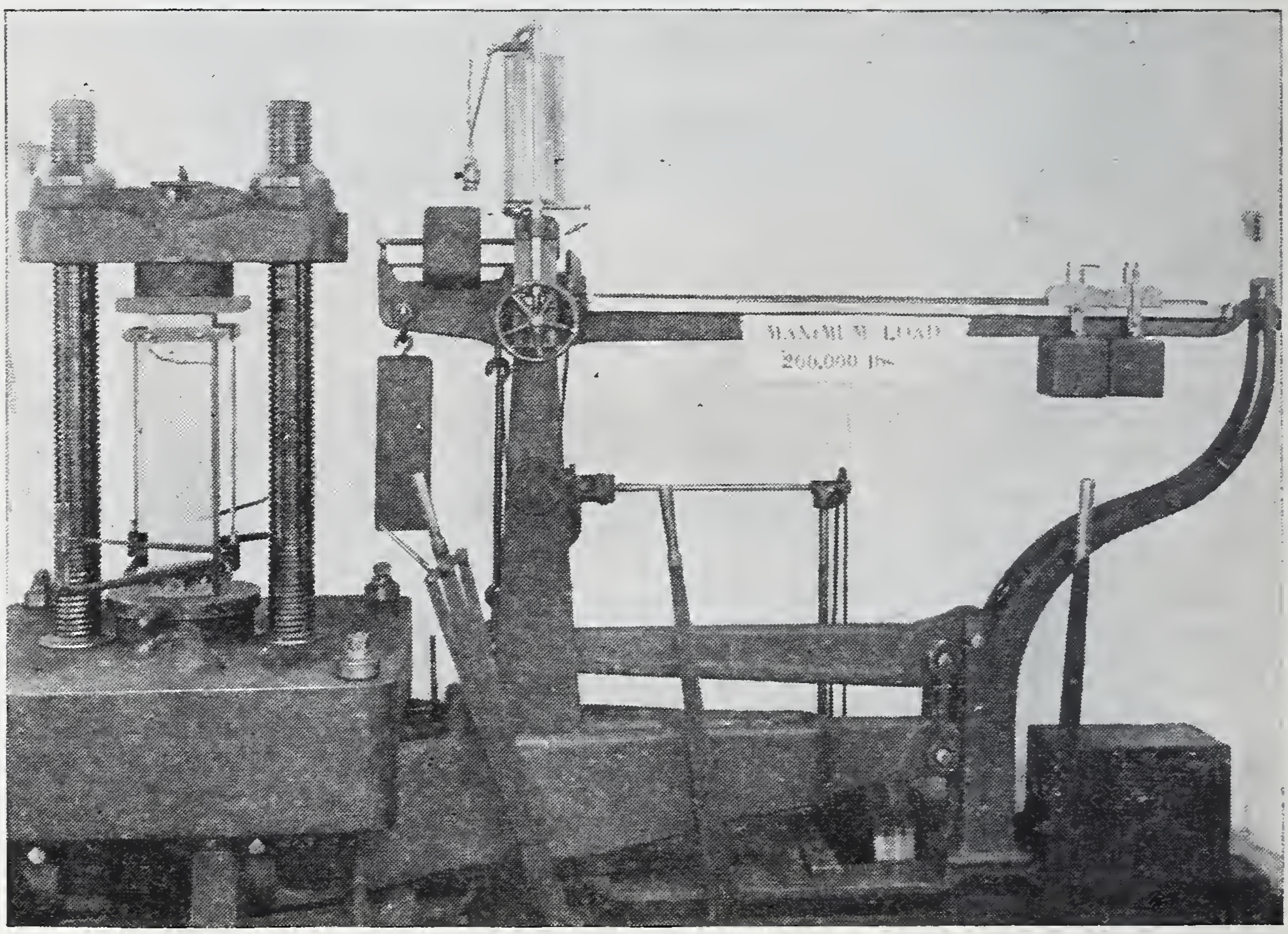

Fig. 60.—Forest Service Method of Making Test to Determine End-Crushing Strength, or Strength in Compression Parallel to the Grain.

Keeping Hardwood Floors in Good Condition

The amount of attention required to keep a hardwood floor in order depends wholly upon the use it is subjected to. All floors should be gone over from time to time and touched up.

In the regular course of housecleaning the housekeeper should remove the dust by pinning a damp soft cloth over an ordinary broom so that the dust will adhere to it more readily, but be sure to wipe dry with a dry cloth immediately afterwards. In case some dirt should adhere to the floor that the damp cloth will not remove, use lukewarm water and soap, being particular to cleanse this off as quickly as possible and wipe dry. For removing stains, use a cloth saturated with turpentine or benzine.

If the finish is dull after giving it a thorough cleaning as recommended above, obtain, at a small cost, some floor reviver, saturate a cloth with it, wring it out half dry and rub the finish until the luster returns.

Every prospective user of maple, beech, and birch flooring will find it to his advantage to write to the Maple Flooring Manufacturers Association, Chicago, Ill., for copies of their booklets.

OAK FLOORING

The Oak Flooring Manufacturers Association, whose office is in Chicago, Ill., distributes an excellent booklet upon oak flooring, from which the following information is taken:

GRADING RULES

Quarter-Sawed Oak Flooring

Clear.—Shall have one face practically free of defects, except ⅜ of an inch of bright sap; the question of color shall not be considered; lengths in this grade to be 2 feet and up, not to exceed 15 per cent under 4 feet.

Sap Clear.—Shall have one face practically free of defects, but will admit unlimited bright sap. The question of color shall not be considered. Lengths in this grade to be 1 foot and up.

Select.—May contain bright sap, and will admit pin-worm holes, slight imperfections in dressing, or a small tight knot, not to exceed 1 to every 3 feet in length; lengths to be 1 foot and up.

Plain-Sawed Oak Flooring

Clear.—Shall have one face practically free from defects, except ⅜ of an inch of bright sap; the question of color shall not be considered; lengths in this grade to be 2 feet and up, not to exceed 15 per cent under 4 feet.

Select.—May contain bright sap, and will admit pin-worm holes, slight imperfections in dressing, or a small, tight knot, not to exceed 1 to every 3 feet in length; lengths to be 1 foot and up.

No. 1 Common.—Shall be of such nature as will make and lay a sound floor without cutting. Lengths 1 foot and up.

No. 2 Common.—May contain every character of defects, but will lay a serviceable floor with some cutting. Lengths 1 foot and up.

Standard Thicknesses and Widths of Oak Flooring

$^{13}/_{16}$-inch thickness; widths 1⅛-inch face, 2-inch face, and 2¼-inch face.

⅜-inch thickness; widths 1½-inch face and 2-inch face.

The 1½-inch face makes a better, more serviceable, and handsomer floor than any other width. The shading of the figure of the wood may be blended more harmoniously than where the wider strips are used.

The 2-inch and 2¼-inch faces are the widths more generally used in $^{13}/_{16}$-inch thickness; and in ⅜-inch thickness, either 1½-inch or 2-inch face, as conditions demand.

Use of Different Grades of Oak Flooring

Clear, Quarter-Sawed, Red or White.—High-class residences, hotels, apartment houses, and club houses.

Sap Clear, Select; Quartered, Red or White.—An economical substitute for Clear Quartered where a dark finish is desired. These grades make a flooring equally as durable as the first grade.

Clear, Plain-Sawed, Red or White.—High-class residences, hotels, apartment houses, churches, and club houses.

Select Plain-Sawed, Red or White.—Medium-priced residences, hotels and apartments, schools, office buildings, and stores.

No. 1 Common.—Cheap dwellings, tenements, stores, high-class factories and manufacturers' buildings.

No. 2 Common.—Warehouses, factories, and cheap tenements.

How to Determine Amount of Flooring Required

To cover a certain space, figure the number of square feet, which means the width multiplied by the length; for instance, a room 12 feet

wide and 15 feet long would contain 12x15=180 square feet. Add to the square feet of surface to be covered, the following percentages:

50 per cent for	$^{13}/_{16}$x1½ inch
37½ per cent for	$^{13}/_{16}$x2 inch
33$^{1}/_{3}$ per cent for	$^{13}/_{16}$x2¼ inch
33$^{1}/_{3}$ per cent for	⅜x1½ inch
25 per cent for	⅜x2 inch

The above figures are based on laying flooring straight across the room. Where there are bay windows, hearths, and other projections, allowance should be made for excessive cutting.

Laying Oak Floors

The laying of oak flooring is not difficult. Any first-class carpenter can make a good job. Some judgment and care are necessary in order to produce the best results.

A sub-floor should be used under both the $^{13}/_{16}$-inch and ⅜-inch thicknesses. The sub-floor should be reasonably dry and laid diagonally. Boards about 6 inches wide are preferred. These boards should not be put down too tight, and should be thoroughly dried off and cleaned before the oak flooring is laid.

It is well to use a damp-proof paper between the oak flooring and the sub-floor. Where sound-proof results are desired, a heavy deadening felt is recommended.

Oak flooring should be laid at right angles to the sub-floor. After laying and nailing three or four pieces, use a short piece of hardwood 2x4 placed against the tongue, and drive it up.

The nailing of oak flooring is very important. All tongued-and-grooved oak flooring should be blind-nailed. The best floor made can be spoiled by the use of improper nails. The steel cut variety is recommended for all blind-nailing.

For $^{13}/_{16}$-inch use 8 penny steel cut flooring nail.

For ⅜-inch, use 3 penny wire cement coated finishing nail.

The maximum distance between the nails should be:

For $^{13}/_{16}$-inch thickness, 16 inches.

For ⅜-inch thickness, 8 inches.

For even better results, it is recommended that the nails be driven closer than indicated.

Scraping Oak Floors

After the oak flooring is laid and thoroughly swept, it should be thoroughly scraped to insure a perfect polished surface. Scraping can be done by one of the many types of power or hand scraping machines that are generally used by contractors and carpenters. Always scrape

lengthwise of the wood, and not across the grain. A floor after scraping should be thoroughly gone over with No. $1\frac{1}{2}$ sandpaper to obtain the best results in finishing. After this, the floor should be swept clean, and the dust removed with a soft cloth. The floor is then ready for the finish.

Finishing Oak Floors

The finishing of an oak floor is an important feature, involving cost, color, and finish desired. Personal taste and artistic or decorative effects are the guide for the floor finisher.

The clear grade of oak flooring should have a natural oak filler—color of oak. For the select and sap clear grades, a light golden oak filler should be used; and, after the floor is filled, it should be gone over with a little burnt umber mixed with turpentine, to darken light streaks. This will make the select and sap clear grades look like the clear grade, except that the color will be slightly darker. In filling the No. 1 common grade, a dark golden oak filler should be employed, and the light streaks should be darkened in the same manner as the select and sap clear grades. With little care in laying this grade, splendid results can be obtained.

First, treat the floor with a paste filler of desired tone, to fill up the pores and crevices. To thin the filler for application, one has a choice of using turpentine, benzine, wood alcohol, or gasoline to get the right consistency. Never use a liquid filler. When the gloss has left the filler, rub off with excelsior or cloth, rubbing against the grain of the wood. This will make a perfectly smooth and level surface. It keeps out dirt and forms a good foundation, which is the keynote for successful treatment of floors. Allow the filler twelve hours to set or dry. Then apply two coats of white shellac before applying the wax treatment. When varnish is to be used, give one coat of filler and one or two coats of varnish.

A wax or varnish finish may be used. The wax finish is preferred by many, due to economy and ease of renewing places that show wear. The renewing may be easily applied by housekeeper or servant.

Wax Finish.—The best method of applying the wax is to take cheesecloth and double it to get added thickness; then fold into a sort of bag. Put a handful of wax inside and go over the floor thoroughly. It will be found that the wax works through the meshes of the cheesecloth and gives an even coating over the floor. This prevents waste and excessive wax in spots. After the floor has been gone over with the wax and allowed to dry about twenty minutes, it is ready for polishing. Rub to a polish with a weighted floor brush, first across the grain of the wood, then with it. A clean, soft cloth may be used in place of the brush if desired. Then a piece of woolen felt or carpet should be placed under the brush to give the finishing gloss. After waiting an hour, a second coat of wax should be applied in the same way and rubbed to a polish.

Varnish Finish.—This is usually more expensive than the wax finish, but it gives a very hard surface, which at the same time is elastic. One or two coats should be applied after the application of the paste filler. Any of the standard hardwood flooring varnishes will give good results.

Floor Oil Finish.—When a high-class finish is not desired, an economical finish can be had by the use of a light flooring oil made expressly for this purpose by many paint and varnish houses and oil makers. It serves as a filler as well as a finish, and is particularly recommended for oak flooring in public institutions, office buildings and stores. This oil keeps the dust from rising and preserves the floor.

How to Care for Oak Floors

Several preparations are put up by varnish and wax manufacturers which give excellent results for cleaning and caring for oak floors and which may be bought at any department, hardware, drug or paint store.

Never use water, oil, kerosene, turpentine, soap, or any other cleaning agents, except as follows:

Shellac Finish.—If water has been spilled upon the floor, turning it white in places, moisten a soft cloth with a little denatured alcohol and lightly rub the spots, which should immediately disappear. Do not repeat this operation too often, however, or the finish will be entirely removed. Shellacked floors sometimes take on a clouded or grayish appearance due to dampness in the air. This condition can usually be greatly improved by the same treatment as above. If the finish has become so soiled that it is desirable to remove it entirely, first scrub the floor with a standard brand of varnish remover (this is preferable to alcohol, as it does not evaporate as rapidly and insures sufficient time to remove the shellac, thus allowing a smooth, even tone) and then bleach it with oxalic acid (one tablespoon to one gallon of water)—never use lye, as it turns the wood black and ruins the surface permanently. After all moisture has evaporated the original finish may be applied.

Varnish Finish.—If the finish has become badly worn, thoroughly scrub it with a brush, a good cleanser and water (never flood the floor). After it has dried out, apply a thin coat of varnish, or in event time cannot be allowed for the varnish to dry, wax may be substituted.

Wax Finish.—Waxed floors should be dusted with a broom covered with canton flannel. Keep a can of wax on hand, and should the finish become worn in the doorways or elsewhere, apply a thin coat, rubbing well into the wood. Allow the wax to dry for one hour and then polish thoroughly. Before rewaxing the floor, scrub it thoroughly with turpentine and a piece of cheesecloth.

Economical Use of Oak Flooring

With the wide use of rugs in both homes and offices, an economical method is to have the center portion of the room laid with oak flooring of a less expensive grade, employing a better grade for the border. When the rug is laid the visible portion of the floor will then be of the very best appearance, at less initial cost. A room measuring 10x12 feet, for example, may have a border 2 feet wide of clear grade (first quality), either plain or quartered; and in the center section, measuring about 6x8 feet, the select plain grade can be used. This procedure represents a saving of 15 to 40 per cent as against using all of the best grade. Care in finishing the select grade will make it closely resemble the clear. This economical method is a common practice among experienced builders. Thin flooring measuring ⅜ inch thick by 1½ inch or 2 inch face can be laid over old floors in old homes and over unfinished sub-floors in new homes at minimum cost. This type of flooring requires less of a cash outlay than carpets or many other types of wood floors and gives satisfactory service.

YELLOW PINE AND DOUGLAS FIR FLOORS

Edge-grain or quarter-sawed yellow pine and Douglas fir flooring are widely used for many of the same purposes as hardwood flooring.

The Southern Pine Association recommends a hard oil finish for yellow pine floors in stores; a shellacked, varnished, and rubbed, or shellacked and rubbed finish for yellow pine floors in apartments, residences, hospitals, etc.; and for bowling alleys and dance halls, several coats of varnish, rubbed and sanded between each coat, while sometimes the varnished surface is also waxed very lightly and rubbed down. For the treatment of yellow pine floors, the association gives the following directions which are based upon the experience of many architects:

Finishing of Southern Yellow Pine Floors

Southern yellow pine flooring may be had in standard widths and long lengths, either in flat-sawed or edgegrain (quarter-sawed). Either gives maximum service, but the flat-sawed is less durable than the edge-grain and is particularly suited for rooms that are to be carpeted or that are not often subjected to moisture. Southern yellow pine edge-grain floors, in durability, hardness and beauty, are absolutely the

equal of the more expensive hardwood floors, and are so recognized by the best authorities. The edge-grain is especially desirable for use in halls, living rooms and dining rooms, and its stubborn wearing quality makes it the perfect floor where severe usage is given large areas. It is easily finished and is not affected by the wettings of periodical cleanings.

Natural Color Finish.—Never lay a southern yellow pine floor until the plastering of the building is on and thoroughly dry.

Floors should be cleaned, smoothed, hand-scraped and sand papered with the grain of the wood and left in perfect condition to receive the work of the painter, the same as any other high class hardwood floor.

Use no Paste Filler on Southern Yellow Pine Floors.—The close compact grain of the wood makes paste filler unnecessary and undesirable.

Be certain that each coat of finish given a floor is thoroughly dry before another is applied.

Avoid so-called liquid fillers—applied as a surface coat and permitted to remain without rubbing off—as there is uncertainty of their drying thoroughly throughout.

Apply a very thin first coat of white shellac cut with pure grain alcohol. Sand lightly with fine sand paper, and apply two coats of best elastic floor varnish.

Use no dull varnish on floors. If a dull finish is desired, rub lightly with oil and pumice stone.

Wax varnished surface if desired.

Stained Southern Yellow Pine Floors.—In staining southern yellow pine floors, as in staining maple floors, the surface first should be given, instead of shellac, a very thin coat of 75 per cent turpentine and 25 per cent linseed oil. When stain is applied directly to the wood it may be absorbed unevenly.

After the light coat is dry and sandpapered, apply one coat of stain of the desired color in 40 per cent linseed oil and 60 per cent turpentine, evenly brushed into the wood. Follow this, when dry, with floor varnish as specified for natural color finish.

Do not attempt to finish a southern yellow pine floor by the use of wax or oil alone. A polished surface will result, but it will not be hard and will soon discolor with dust and dirt.

The specifications for finishing yellow pine floors apply equally well to Douglas fir floors.

CHAPTER XIII

FIRE-RESISTANCE

The fact that wood will burn if heated hot enough, has been the basis of a great hue and cry against wood by certain interests whose purposes would be better served were wood completely banished from all forms of construction. The agitation against the use of shingles in cities has gone so far that an individual whose main business is propaganda declares that a shingle roof is "not a covering but a crime." As a matter of fact, however, the records generally show that a larger proportion of fires in the United States are due to carelessness than to any one form or material of construction. Moreover, for many medium-sized factory buildings, what is called "standard mill construction" is more desirable than so-called "fireproof" construction. With proper safeguards, there is little danger from fire in mill-constructed buildings; and structures of this type have been known in a number of instances to stand up better under fire than have buildings of similar character with steel framework.

NATURAL FIRE-RESISTANCE

Not all woods are susceptible to fire in the same degree. Indeed, at the lower temperatures, there is a considerable range between the different woods in the resistance which they offer to ignition. Still further, the ease with which wood burns depends upon its moisture content, a piece of dry wood catching fire, of course, much more quickly than a moist piece.

The Forest Products Laboratory made an interesting series of tests upon the natural fire-resistance of a number of species of timber. The results of these tests are shown graphically in figures on pages 168 and 170. It will be noted from

these tests, that in the case of the Western woods, Western larch resisted ignition longest; and that among the Eastern woods, tamarack or Eastern larch held the same position. In fact, tamarack seems to be the most fire-resistant of eight woods tested. Curve A shows for example, that it was necessary to expose a piece of air-dry tamarack to a temperature above 205° C (or 401° F) for 40 minutes, in order to make it burn; while Curve F shows that a piece of oven-dry longleaf pine ignited in 15 minutes at a temperature of 175° C (or 347° F). On the other hand, air-dry tamarack and air-dry longleaf pine were both held at a temperature of 180° C (or 356° F) for 40 minutes, without ignition. When, however, the temperature became as great as 350° C (or 662° F), there was little difference in any of the species in resistance to ignition.

ARTIFICIAL FIRE-RESISTANCE

The attacks which have been made upon wood as a building material, and the desire to increase its fire-resistance, have greatly stimulated studies to devise a cheap and effective means of fireproofing timber. It has been known, of course, for many years, that wood can be impregnated with salts which will make it practically incombustible; and such fireproofed wood has been used a considerable extent for interior work for a long time. This, however, is quite different from the general fireproofing of shingles and of wood used in building exteriors where it is subject to all the action of the elements. Fire resisting chemicals and methods of using them are known, but thus far they are too expensive for general use. The problem is to do the work cheaply. Both private and governmental agencies are at work on the subject and no doubt the problem will ultimately be solved.

The Forest Service experiments with chemical fire retardants have included tests of sodium carbonate, sodium bicarbonate, oxalic acid, borax, ammonium phosphate, ammonium sulphate, and ammonium chloride. The first three did not prove efficient in retarding combustion. Borax has been found to have considerable value for fireproofing purposes, while wood thoroughly impregnated with ammonium salts would

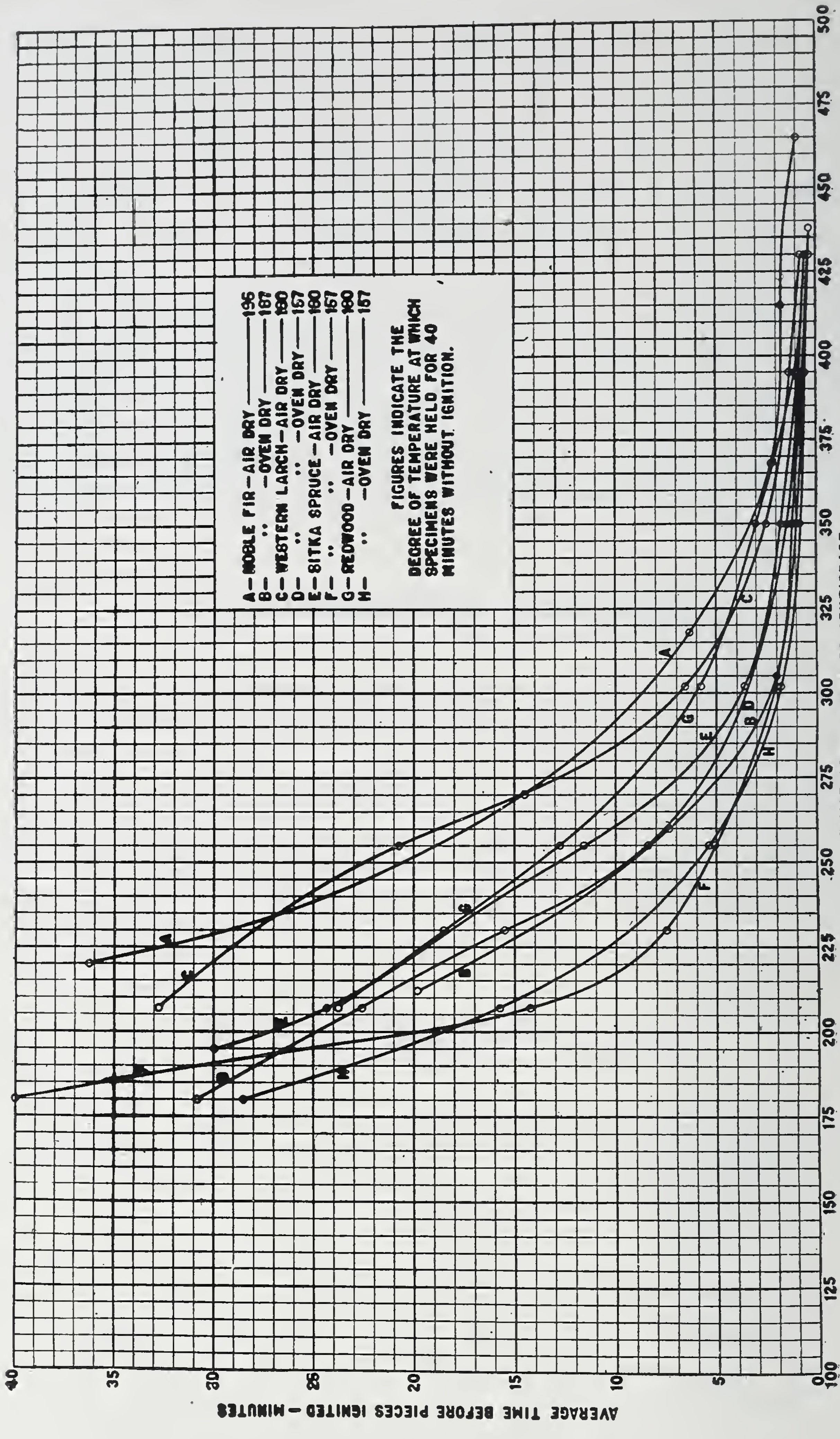

Fig. 61.—Chart Showing Fire-Resistance of Various Western Woods.

not support combustion under the Service conditions of test. The progress which has been made along this line as the result of only a short period of experimentation, leads the Forest Service engineers to the conclusion that it is possible to devise a reasonably inexpensive method of fireproofing wood, while firms already in the market claim that it is possible to do this on a commercial scale. It is not likely, therefore, that the opponents of wood construction will much longer be able to maintain that it is impossible to make wood resistant to fire where fireproof construction is necessary.

COMMERCIAL FIREPROOFING

The fireproofing of wood on a commercial scale is thus described by Mr. F. C. Schmitz, Vice-President of the Standard Wood Treating Company, New York, N. Y.:

The fireproofing of wood, as at present practiced commercially, is accomplished by saturating its fibers with a water solution of chemicals which, in the presence of fire, emit a gas that prevents combustion. To accomplish this, the wood to be treated is loaded on suitable cars, and placed in a cylinder from which the air is exhausted. The above-mentioned solution is then let into and completely fills the cylinder. Hydraulic pressure is then applied, by means of a pump, of such a degree and for sufficient time to force the chemical solution into and through the wood, to the point of saturation. Upon reaching this latter point, the cylinder is drained of solution, and the lumber removed.

When it is necessary that the treated lumber shall be thoroughly dry before it can be used, it is kiln-dried to evaporate the water in the solution, leaving the chemicals in the pores of the wood in dry crystal form.

It is not claimed for the product that it is fireproof in the sense of being, like firebrick, indestructible in the presence of fire, but that it will not support or communicate combustion. Any organic substance will be destroyed by fire if left in its presence for a sufficient length of time.

An important fact in connection with the use of fireproof wood, is that it is fireproofed with water-soluble chemicals; and therefore, if, after treatment, it is exposed to water (such as rain), the chemicals again dissolve and are removed from the wood, with a consequent reduction in its resistance to fire. Any wood, therefore, intended for outside use, should be protected from the weather by a waterproof coating, such as paint or varnish.

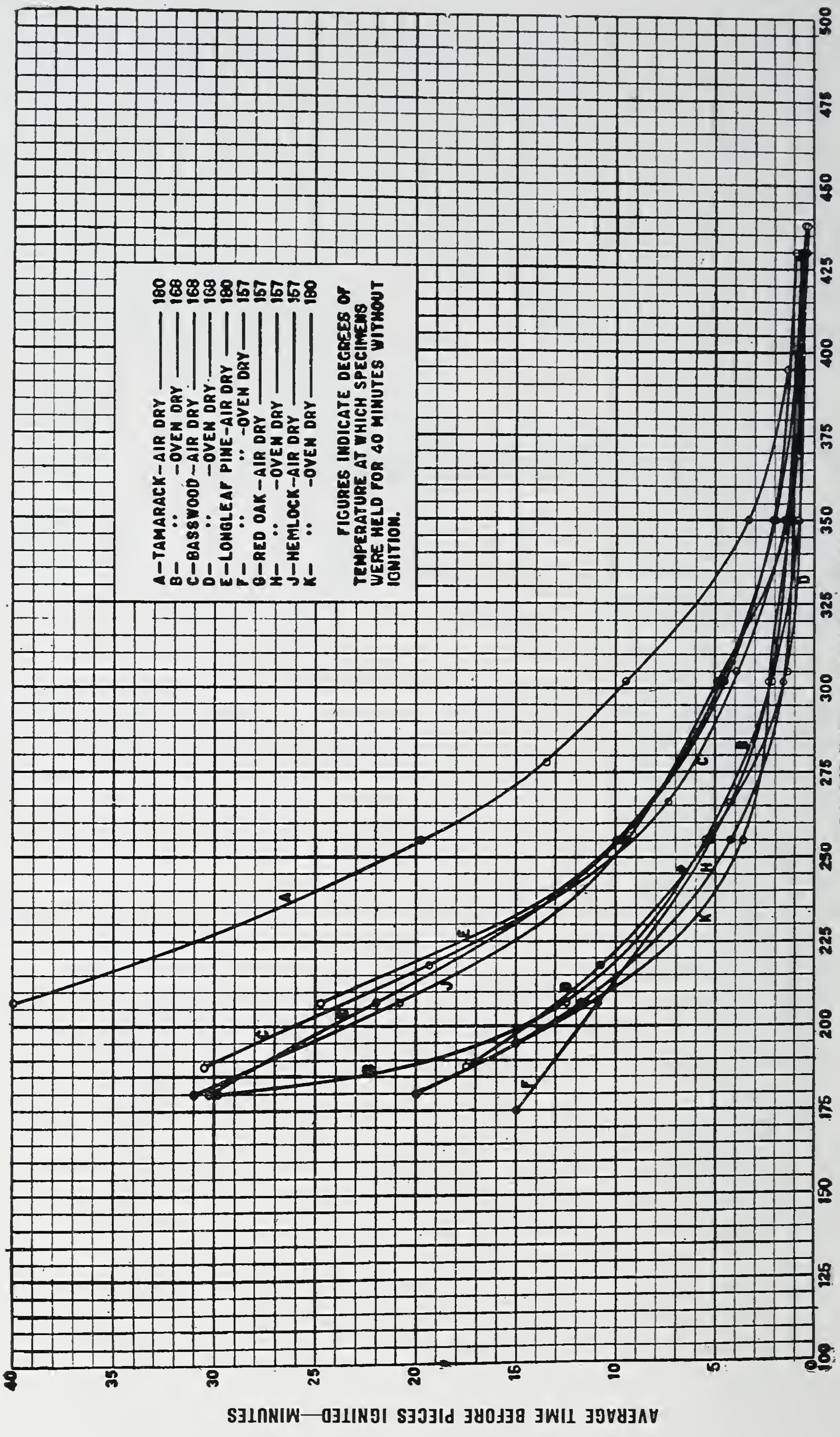

FIG. 62.—Chart Showing Relative Fire-Resistance of Various Eastern Woods.

Fireproof wood has been used largely for interior work, principally in the city of New York, where the Building Code provides for its use in all buildings over 150 feet or twelve stories in height. It has, in addition, had a considerable use in residences and in various trades, for special purposes.

The treatment is permanent so long as no water is permitted to soak into the wood; and samples taken from buildings after fifteen years' service show as good results as freshly treated lumber. The treatment slightly hardens and in some cases darkens the wood. It does not, however, affect its strength or impair its beauty.

The process is comparatively inexpensive, when results are considered; and ultimately its use must be widespread, especially in isolated buildings where fire-fighting facilities are not of the best, and where fire would result in large damage to business.

Many corporations and firms in the east are now beginning to realize this point, and there is a constantly increasing demand for the product for such uses.

FIRE-RETARDANT PAINTS FOR SHINGLES

Under this title, Henry A. Gardner, Director of the Institute of Industrial Research, Washington, D. C., discusses the latest results of his tests of fire-resistant paints as applied to shingles. In the first place, he calls attention to the low heat conductivity of a shingle roof in the following language:

The writer conducted a series of laboratory tests to determine the heat deflecting properties of various types of roofing materials. Miniature houses were roofed with bare shingles, painted shingles, tin, and stone. Thermometers were inserted in the end of each house. The houses were placed in an oven heated to 150° C. At the end of 15 minutes, thermometric readings were taken. The interior of the houses roofed with stone and tin showed a much higher temperature than those roofed with shingles. The house with the roof covered with painted shingles showed the lowest temperature. On account of the heat deflecting properties of shingles, they will probably always find a wide application in warm climates. Shingled dwellings are much cooler in the summer than iron-clad or stone-roofed dwellings.

After mentioning the usual objections that are made to shingle roofs as sources of fire danger, Mr. Gardner continues:

Although the writer has pointed out many disadvantages of the wooden shingle, the situation is not as serious as it might at first

appear. Very few structural materials have ever been made which have proved satisfactory for roofing or other building purposes, without some surface treatment. If iron or steel sheets are exposed to the weather, they will rapidly corrode and rust away to a mere lace-like skeleton of their original form. The application of suitable paint coatings at proper intervals, will, however, preserve such metal sheets for an indefinite period of time. Nearly all forms of cement or stone work will check, crack, absorb large quantities of moisture, and become unpleasing in appearance, unless properly treated with protective paints. The weather-boarding and wooden trim of all kinds of structures would soon rot and decay if left in an unpainted condition. It is evident that "paint is the preserver of all things structural," and that we must look to the use of paint for the solution of the problems under consideration.

Two Groups of Fire-Retarding Paints

Fire-retarding paints may properly be divided into two groups, one of which is represented by oil-mineral paints, and the other by paints which do not contain oil. The term mineral paint refers to that type of paint which is so widely used throughout the rural districts to decorate and preserve dwellings, barns, and similar outbuildings. In the manufacture of these prepared mineral paints, various mineral pigments in a finely divided and carefully prepared form are ground in linseed oil, and mixed with the proper driers and thinners. The content of mineral pigment in such paints varies from 50 per cent to 70 per cent of the total. When such paints are applied to shingles, a very durable, waterproof film results. This film of dried paint upon the surface of a shingle has the effect of laying or smoothing down the rough, fuzzy surface of the wood, thus eliminating at once an important source of fire danger. The paint film, moreover, is quite as resistant to moisture as a sheet of India rubber. The shingled dwelling upon which such paint has been used is practically rain-proof. It is, moreover, made very attractive in appearance.

Another important function is performed by the paint, in preventing the warping of shingles at the edge, thus doing away with the formation of pockets in which hot cinders might lodge and burn.

The fourth and most valuable characteristic of mineral paint is its resistance to fire. While the oil content is more or less combustible, there is present in the dried paint film a minor proportion of oil, the major proportion consisting of mineral pigments which are unaffected by fire. A hot cinder or spark, falling upon a roof properly treated with a high-grade mineral paint, would, in most instances, roll from the roof to the ground. There would be no pockets in which to lodge and burn. In the event of hot cinders falling with great force upon relatively flat roofs, the cinders would probably lodge upon the surface and burn away the superficial coating of dried oil, gradually dying out as they reached the fire-resisting mineral pigment.

Prepared mineral paints of good grade may be obtained at a moderate price at any modern paint shop. They are, therefore, within the reach of anyone who desires to use them for protecting shingled structures. If made by a reputable manufacturer, the purchaser may be sure that they are prepared from properly selected mineral pigments, carefully mixed with oil, and finely ground, through rapidly revolving stone and steel mills, to a smooth condition. For coating shingles by dipping, such paints could be furnished in a thinner condition than for brushing. It is the writer's belief, however, that better results will be obtained if a heavy coat of paint is brushed upon the shingles, as in this case a greater amount of paint will become embedded within the surface of the wood, and the dried coating will contain a greater percentage of fire-resisting mineral.

Value of Impregnation Process

It is obvious that the application of brush coats of salts to wooden shingles would not result in the formation of weather-resisting surfaces. It is the writer's belief, however, that a shingle manufacturer can at moderate cost impregnate shingles with certain mineral salts which will make them more resistant to fire. Wooden beams and railroad ties are often rendered more durable by treatment with preservatives possessed of fungicidal properties, such, for instance, as creosote or zinc chloride. These chemical substances are forced deeply into the wood by special processes. It would, in the writer's opinion, be practicable for the shingle manufacturer to adopt a similar process for mineralizing shingles. Mineral salts having a high resistance to fire could be used for the impregnation base. Shingles thus mineralized could be rendered still more resistant to fire by subsequently applying a coat of mineral paint. The writer has experimented with various salts for this purpose, and has treated shingles with their solutions, both by brushing and by dipping.

Shingles thus treated have shown much greater resistance to fire. The best results were obtained by mineralizing the shingles and subsequently coating them with mineral paint. The mineralizing process of making the wooden shingle thoroughly safe as a roofing material should be carried out in two steps. The shingle manufacturer should undertake the first process of treating the shingle with fire-resisting salts. If shingles thus impregnated are furnished the builder, it is quite certain that he will carry out the second and most important part of the process, which consists in applying a decorative and waterproof coating of fire-resistant mineral paint. It will, of course, be possible to use the old-style creosote shingle stain over the mineralized shingle, in place of a mineral paint. However, the mineral paint will give much more satisfaction, as it forms a durable, waterproof film which is more resistant to fire than an ordinary stain.

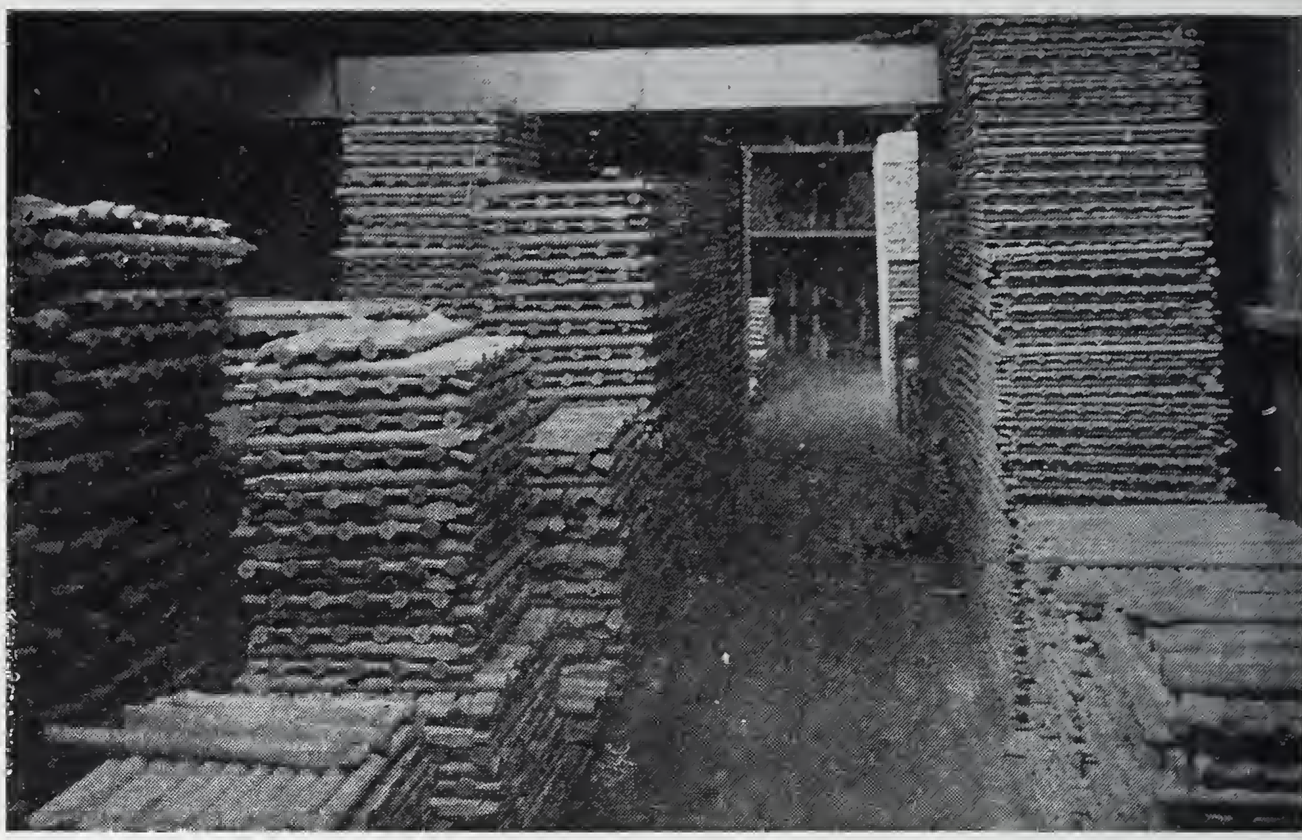

FIG. 63.—Drying Room in a Vehicle Factory, Showing Oak and Hickory Spokes and Elm Hubs.

FIG. 64.—Drying Room in a Vehicle Factory, Showing Oak and Hickory Rims for Buggy Wheels; also Birch and Elm Hubs.

VEHICLE FACTORIES

Mr. Gardner outlines in detail methods for making and testing fire-retardant paints, and concludes the discussion with these statements:

The shingled roof is highly desirable on account of its durability, light weight, low cost, and non-conductivity of heat properties.

Shingled roofs are subject to conflagration when they become dry. Hot cinders from chimneys or glowing sparks carried by the wind from nearby fires, are common causes of roof fires.

The use of high-grade mineral paints upon shingled roofs eliminates such fire danger. Shingled structures of all types, when properly painted, are not only fire-resistant, but they are moisture-proof and highly ornamental.

The painted shingle dwelling constitutes one of the most desirable types of modern suburban homes.

CHAPTER XIV

LUMBER PRICES

Many well-informed people have the impression that lumber has become so scarce and high-priced that the ordinary man can no longer afford to build a wooden house. This impression, like the agitation against wood construction on account of fire risk, has been assiduously cultivated by the vendors of substitute materials. It is true that certain grades of some species of timber are high-priced, compared with the price at which the same grades could be obtained 20 to 30 years ago; but, on the other hand, there is still much good building material available for every purpose, at reasonable cost. While some kinds are scarcer than they once were, we are now using many valuable woods which were formerly wholly neglected. The last fifteen years has seen tremendous advances in the appreciation of red gum, beech, birch, maple, and the West Coast woods. While the highest grades of nearly all kinds of timber command high prices, because only a small amount of high-grade lumber is produced, we must remember that the ordinary structural materials consist of the medium grades, of which there is a much greater supply than of the higher grades. These medium grades have not had the same advance in price as the upper grades, owing both to their abundance and to the competition of other materials. The same causes will prevent their advance to excessive prices for many years to come; hence these grades will continue for a long time to be the chief reliance of builders in many parts of the country.

The advance in the price of lumber during and following the World War was relatively no greater than that of many other commodities. Table 15, based on data compiled by the Census Bureau and the Forest Service, shows the average values per thousand feet at the sawmill, of the principal kinds of lumber. The average price of $38.42 for all woods in 1920,

as shown in Table 15, is more than two and one-half times the average price of $15.05 shown for 1911. However, the average mill price for all woods of $23.47 realized by the manufacturers in 1921 during the business slump of that year was

TABLE 15

AVERAGE MILL PRICES OF PRINCIPAL KINDS OF LUMBER

(Per Thousand Feet, Board Measure)

Kind of Wood	1921	1920	1919	1918	1917	1916	1915	1911	1909	1899
All kinds......	$23.47	$38.42	$30.21	$24.79	$20.32	$15.32	$14.04	$15.05	$15.38	$11.13
SOFTWOODS:										
Yellow pine....	19.42	35.89	28.71	24.38	19.00	14.33	12.41	13.87	12.69	8.46
Douglas fir....	18.04	34.59	24.62	18.77	16.28	10.78	10.59	11.05	12.44	8.67
Western yellow pine........	26.95	38.73	27.75	20.87	19.59	14.52	14.32	13.62	15.39	9.70
Hemlock......	20.79	32.05	29.16	23.97	20.78	15.35	13.14	13.59	13.95	9.98
White pine....	30.03	41.49	32.83	30.84	24.81	19.16	17.44	18.54	18.16	12.69
Spruce........	25.73	38.94	30.76	28.65	24.41	17.58	16.58	16.14	16.91	11.27
Cypress.......	36.88	51.02	38.38	30.56	23.92	20.85	19.85	20.54	20.46	13.32
Redwood......	40.57	46.90	30.04	24.30	21.00	13.93	13.54	13.99	14.80	10.12
Larch (Tamarack)..	15.56	30.28	23.39	19.86	16.21	12.49	10.78	11.87	12.68	8.00
White fir......	21.37	30.44	25.66	19.61	17.16	12.25	10.94	10.64	13.10	(*)
Cedar.........	38.55	38.68	33.80	24.86	19.40	15.24	16.10	13.86	19.95	10.91
Sugar pine.....	37.83	48.76	35.99	28.26	24.69	16.77	17.40	17.52	18.14	12.30
Balsam fir.....	25.71	34.33	32.23	27.27	20.02	16.49	13.79	13.42	13.99	(*)
Lodgepole pine.	21.81	30.58	29.98	20.95	18.34	15.13	13.57	12.41	16.25	(*)
HARDWOODS:										
Oak..........	30.56	46.88	37.87	31.11	24.49	20.06	18.73	19.14	20.50	13.78
Maple........	30.34	50.16	35.56	29.05	23.16	18.24	15.21	15.49	15.77	11.83
Gum, red and sap.........	22.46	35.24	32.68	23.21	19.56	14.64	12.54	12.11	13.20	9.63
Chestnut......	27.87	42.48	32.30	27.31	21.54	17.05	16.17	16.63	16.12	13.37
Birch.........	31.53	53.44	35.79	29.94	24.07	19.59	16.52	16.61	16.95	12.50
Yellow poplar..	37.31	58.87	41.65	35.06	27.17	21.89	22.45	25.46	25.39	14.03
Beech.........	26.99	36.51	29.97	25.06	19.58	16.20	14.01	14.09	13.25	(*)
Elm..........	29.63	47.23	36.39	28.19	22.89	19.46	16.98	17.13	17.52	11.47
Basswood.....	33.09	54.28	40.03	34.00	25.96	21.05	18.89	19.20	19.50	12.84
Tupelo........	18.59	33.68	28.42	22.73	18.06	13.00	12.25	12.46	11.87	(*)
Ash..........	38.18	61.28	52.69	38.70	30.01	23.85	22.15	21.21	24.44	15.84
Cottonwood...	25.05	33.38	32.24	26.13	23.19	17.42	17.36	18.12	18.05	10.37
Hickory.......	36.60	52.57	44.37	37.95	29.48	23.84	23.35	22.47	30.80	18.78
Walnut.......	88.83	88.92	72.13	77.60	72.99	42.38	48.37	31.70	43.79	36.49
Sycamore......	22.55	32.12	30.42	23.59	18.68	14.65	13.86	13.16	14.87	11.04

* Not reported separately.

FIG. 65.—Interior View of a Table Factory in Virginia.

FIG. 66.—Interior of a Box Factory. Finished Sides, Tops, and Bottoms are Bundled Ready to be Shipped to the User Who Will Assemble Them

TABLE AND BOX FACTORIES

39 per cent below the 1920 average, while the 1923 figures were about 20 per cent below the peak attained in the spring of 1920.

The statement that lumber has reached such an exorbitant price that it can no longer be used, is best met by the records of the United States Department of Labor, an authority on the wholesale prices of all commodities. In the January (1923) issue of the monthly Labor Review of the Department is given a table of the relative prices of various groups of commodities for each month 1913 to 1922, the average price for 1913 being taken as 100. The chart (Fig. 67) shows in graphic form the record of the Department for three of the most important groups of commodities—farm products, food, and lumber and building materials, and for all products. On the chart, farm products are indicated by a dotted line, food by a line of dots and dashes, and lumber and building materials by a line of dashes. The solid line represents all commodities. A single glance at the chart completely answers the statement as to the undue advance in lumber prices. On an average, lumber and building material prices have run between the prices of farm products and of food for the last 50 years. Still further, prices of lumber and building materials are relatively lower now than they were 40 years ago; yet at that time no one thought that lumber was too expensive with which to build.

COMPARATIVE BUILDING COSTS

Another way of approaching the same problem is through a comparison of the cost of wood construction with that of other materials. The United States Department of Commerce in its index of building material prices (Survey of Current Business, May, 1923) shows the 1922 monthly average index figure for frame house construction to be 182 and that for brick house construction 186. In each instance 1913 is used as the base or 100. The index is computed on the prices which are weighted by the relative importance of each commodity used in the building of a six-room house.

Interesting figures also have been issued by the Department of Commerce showing the per cent of cost each material

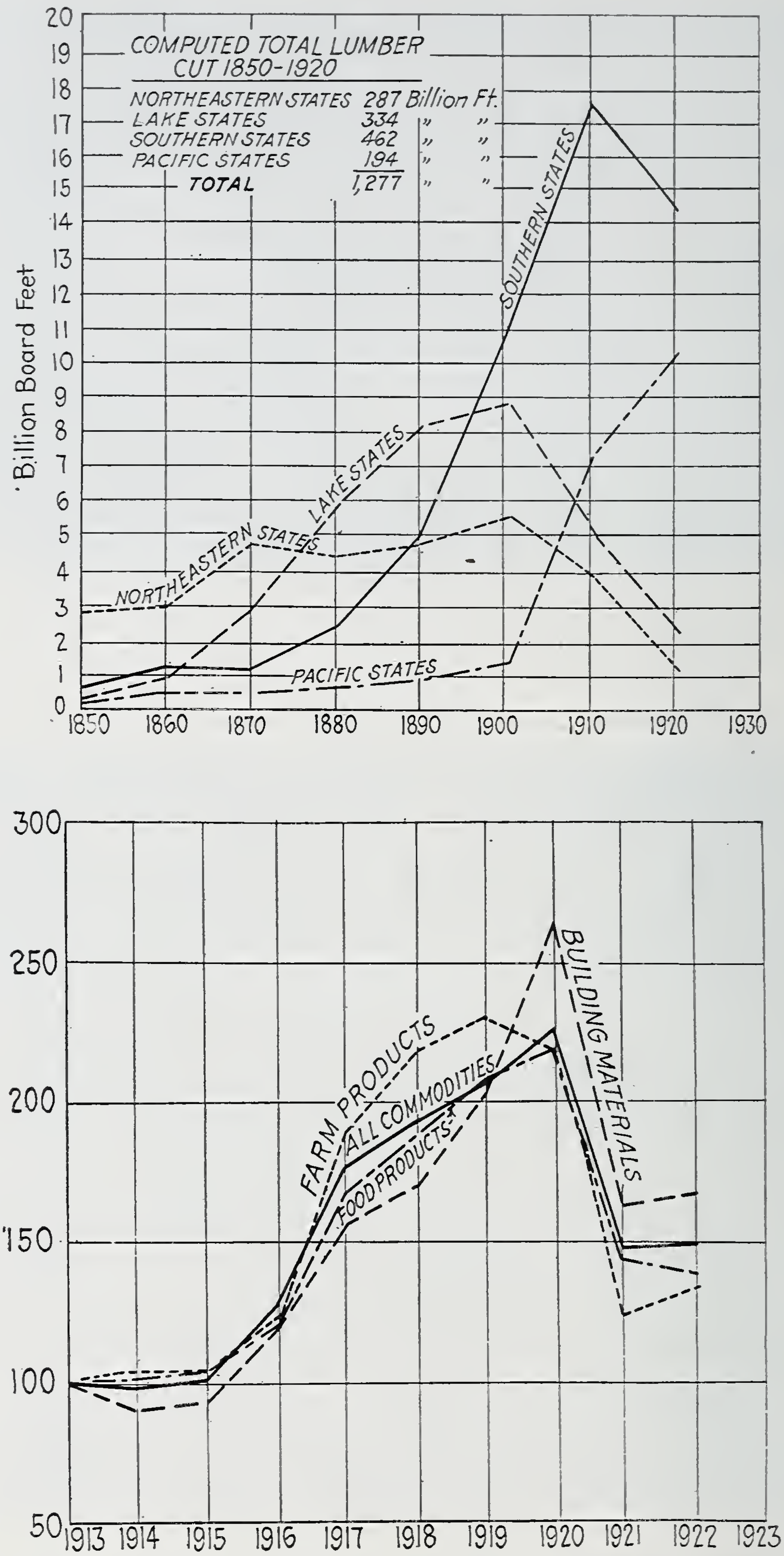

Fig. 67.—Chart Showing Price Fluctuations of Lumber and Building Materials as Compared with Farm Products, Food Products, and all Commodities.

item bears to the total material cost of a six-room frame house. The data were compiled from operations in 1921.

Item	*Average Per Cent*
Lumber	45.0
Brick	4.2
Cement	3.5
Sand	2.4
Lime	2.2
Glass	2.3
Lath	2.6
Plumbing	10.3
Heating equipment	8.4
Electric equipment	3.6
Roofing	5.6
Finishing hardware	2.5
Paint and varnish	4.0
Miscellaneous	3.4
	100.0

Labor costs and their per cent distribution according to the several class groups in the construction of a six-room house are shown in the appended table. The averages were computed from reports to the Department of Commerce covering a large number of six-room frame and brick houses throughout the country. The relation of the amount paid to the various groups to the total labor cost varies according to the types of construction prevailing in the various localities; however, these averages give a fair view of the general distribution of labor costs.

Trade Group	*Frame House*	*Brick House*
Carpenters	49.6	32.2
Bricklayers	6.2	21.5
Hod carriers	2.2	6.7
Plasterers	7.9	8.8
Plumbers	8.7	7.6
Electricians	2.6	2.5
Painters	10.0	6.3
Common laborers	6.3	9.9
All others	6.5	4.5
Totals	100.0	100.0

Radford discusses the same problem on the basis of construction cost, per square yard of finished wall surface, of frame, of plain brick veneer, and solid brick construction, on the theory that the roof, foundations, floors, windows, interior finish, etc., are practically the same in each type, save that in brick construction the cost of stonework for sills, lintels, etc., must be added. The figures are for the pre-war period and are subject to substantial increase to make them entirely applicable to present day conditions. His estimates for the cost of plain wall construction of the three types are as follows:

Frame Construction

(Per square yard of finished wall surface)

Dimension lumber, 8 ft. B. M., at 4c per ft. (in wall)	$0.32
Sheathing, 10 ft. B. M., at 4c per ft. (in wall)	.40
Siding, 12 ft. B. M., at 4½c per ft. (in wall)	.54
Building paper, put on, per yd.	.03
Painting, two coats, per yd.	.18
Plastering, three coats, per yd.	.26
Total, per sq. yd.	$1.73

Brick Veneer Construction

(Based on cost of face brick at $21.00 per 1,000)

Dimension lumber, 8 ft. B. M., at 4c per ft. (in wall)	$0.32
Sheathing, 10 ft. B. M., at 4c per ft. (in wall)	.40
Building paper, put on, per yd.	.03
63 face brick, at 3½c each (in wall)	2.21
Plastering, three coats, per yd.	.26
Total, per sq. yd.	$3.22

Solid Brick Construction

(12 in. wall)

63 face brick, at 3½c each (in wall)	$2.21
126 common brick, at $14 per 1,000 (in wall)	1.76
Furring walls, per yd.	.06
Plastering, three coats, per yd.	.26
Total, per sq. yd.	$4.29

In conclusion, Radford states that, adding to each type of construction the cost of floors, doors, roofs, interior finish, etc., and dividing by the total number of square yards of wall surface, it is found that the cost of brick veneer construction is often 20 to 25 per cent greater than of frame construction, and that solid brick construction is about 40 per cent more expensive than frame construction.

It is often claimed that stucco on metal lath is now cheaper than lumber for the exterior of houses. There may be cases in which the first costs compare favorably. It must be remembered, however, that stucco is not waterproof, that metal lath will rust sooner or later, and that this type of construction has not had a long enough period of service behind it so that we can be at all sure of its permanence. The builder of wood can point to numberless instances of wooden siding on houses which has given good service for 50 years or more, and to many cases of durability of more than 100 years. So he does not begrudge the occasional coat of paint that the substitute advocate claims is not necessary for his own particular product.

CHAPTER XV

THE USES OF LUMBER

The United States Forest Service, in many cases with the assistance of State authorities, has made studies of the more important wood-using industries, so that there is now available a summarized report covering every large industry. The report deals chiefly with the consumption of sawed lumber; but a few industries are included in which raw material goes to the factory in log or bolt form. For such industries, the wood consumed has been reduced to board feet to afford a proper basis for comparison with the requirements of other industries. Although both the total lumber consumption and the uses of the various species unquestionably vary somewhat from the available statistics, the figures presented are valuable for purposes of estimate and comparison.

Grouped in order of magnitude and stated in round numbers, it appears that the present annual wood consumption (chiefly in the form of lumber) for building and factory uses, in the United States, is approximately the amount shown in Table 16.

TABLE 16

ANNUAL WOOD CONSUMPTION FOR VARIOUS SPECIAL PURPOSES

Purpose	Million Board Feet
1. General Building and Construction	13,500
2. Planing Mill Products	12,750
3. Boxes and Crates	4,000
4. Furniture and Fixtures	1,200
5. Car Construction	1,070
6. Vehicles (including automobiles)	850
7. Woodenware, Novelties, etc	340
8. Agricultural Implements	270
9. Handles	250

TABLE 16—*Continued*

Purpose	Million Board Feet
10. Musical Instruments	220
11. Tanks and Silos	190
12. Ship and Boat Building	170
13. Caskets and Coffins	130
14. Refrigerators and Kitchen Cabinets	120
15. Excelsior	85
16. Matches and Toothpicks	72
17. Laundry Appliances	68
18. Shade and Map Rollers	67
19. Paving Materials and Conduits	65
20. Trunks and Valises	64
21. Machine Construction	59
22. Boot and Shoe Findings	56
23. Picture Frames and Moldings	55
24. Shuttles, Spools, and Bobbins	55
25. Tobacco Boxes	54
26. Sewing Machines	51
27. Pumps and Wood Pipe	48
28. Automobiles (included with Vehicles)	
29. Pulleys and Conveyors	31
30. Professional and Scientific Instruments	30
31. Toys	25
32. Sporting and Athletic Goods	21
33. Patterns and Flasks	20
34. Bungs and Faucets	18
35. Plumbers' Woodwork	17
36. Electrical Machinery and Apparatus	15
37. Brushes	11
38. Dowels	10
39. Elevators	9
40. Saddles and Harness	8
41. Playground Equipment	8
42. Insulator Pins and Brackets	8
43. Butcher Blocks and Skewers	7
44. Clocks	7
45. Signs and Supplies	6
46. Printing Materials	4
47. Weighing Apparatus	4
48. Whips, Canes, and Umbrella Sticks	4
49. Brooms and Carpet-Sweepers	1
50. Firearms	1
51. Other and Minor Uses	1
Total	36,125

1. General Building and Construction.—Probably about 40 per cent of the total lumber production of the United States goes directly from the sawmill into general building and construction, without passage through an intermediate woodworking factory. This includes all ordinary lumber used for structural work, sheathing, roofing, fencing, etc. Almost every kind of wood is used to some extent for these purposes; but the chief building material is the softwoods, because they are more easily worked, lighter, and usually cheaper than the hardwoods in the grades suitable for building purposes.

2. Planing Mill Products.—Planing mill products (flooring and finishing lumber, sash, doors, blinds, etc.) are closely connected with the use of general building material, and consist of almost every kind of native and foreign timber. The softwoods—especially yellow pine, Douglas fir, Western pine, and white pine—are the principal woods used for sash and doors, while many kinds of hardwoods are used for flooring and interior finish.

Among the more costly native and imported woods which are utilized for millwork, are mahogany, black walnut, cherry, Circassian walnut, padouk, prima vera, teak, ebony, sandalwood, Spanish cedar, rosewood, koa, and holly. Some of these are used chiefly for inlaid work, and others for panels. Altogether, the government reports indicate the use of more than 60 kinds of wood in the planning mills and sash and door factories of the United States. Planing mills are commonly connected with sawmills in the large lumber producing regions, and are also operated as separate establishments in many central and eastern states.

3. Boxes and Crates.—The manufacture of boxes and crates consumes about 11 per cent of the annual lumber output of the United States; and while no other industry uses a larger variety of woods, it is noteworthy that white pine and yellow pine supply 50 per cent of the box material.

Among the most desirable qualities in box-making woods are lightness, strength, nail-holding power, and a surface upon which names and descriptions can be easily printed. For this reason the softwoods and the softer hardwoods have always been in demand for box making. The lower grades of lumber

are mostly used, since they are cheap and their defects can be cut out in the process of manufacture.

Virginia is the leading box-making state, with a consumption of more than 400 million feet of lumber annually for this purpose. Illinois, New York, Massachusetts, and California are rather close competitors in the quantity of material used for box making. Next in order come Michigan, and New Hampshire; other states particularly Oregon and Washington also are large producers of boxes and box shooks.

The percentage of the total quantity of lumber used in the manufacture of boxes and crates, supplied by the leading species, is indicated in Table 17.

TABLE 17

BOXES AND CRATES

(Annual lumber consumption, 4,000 million board feet)

Woods Used	Per Cent
White Pine	25
Yellow Pine	25
Red Gum	9
Spruce	7
Western Pine	6
Cottonwood	5
Hemlock	4
Yellow Poplar	4
Maple	2
Birch	2
Basswood	2
Beech	2
Tupelo	2
Elm	1
Oak	1
Balsam Fir	1
Cypress	1
Other Woods	1
Total	100

4. Furniture and Fixtures.—Next to box making, the manufacture of furniture and fixtures requires more lumber than any other industry, although less than one-third as much as for

boxes. The percentage of the total supplied by the more important woods is shown in Table 18.

TABLE 18

FURNITURE AND FIXTURES

(Annual lumber consumption, 1,200 million board feet)

Woods Used	Per Cent
Oak	38
Maple	11
Red Gum	8
Birch	7
Yellow Poplar	5
Chestnut	4
Beech	4
Elm	3
Basswood	3
Yellow Pine	2
Mahogany	2
Others	13
Total	100

Because of its beautiful figure, hardness, wearing qualities, and susceptibility to finishes and polish, oak has always been a leading furniture wood. The strength and hardness of maple likewise place it high as a furniture wood; while the figure, color, and receptivity to stains give red gum and birch a large field of usefulness in furniture making. Many beautiful and rare imported woods from all quarters of the earth are also used to secure especially righ and decorative effects.

A large number of woods are used in furniture making which do not appear in the surfaces of the finished article. These are for backing, lining, and interior reinforcement to give strength and to furnish the foundation for the more expensive woods, which are generally used as veneer in order to reduce cost or to get better effects than are possible with solid stock.

Figures indicate North Carolina to be the largest furniture and fixture producing state in the union. Next in importance

ranks Illinois, closely followed by New York, Indiana, Michigan, Wisconsin, and Pennsylvania.

5. Car Construction.—Some forty kinds of wood are used in the construction of freight, passenger, parlor, sleeping, and dining cars; but over half the total quantity is supplied by yellow pine, and nearly one-fourth by oak. Yellow pine, oak, and Douglas fir are used where great strength is required for sills, brake-beams, posts, bolsters, plates, etc. Yellow pine, Douglas fir, Norway pine, Western hemlock, and cypress are used for car siding, roofing, and similar purposes; yellow poplar, for panels; and ash, oak, red gum, mahogany, birch, cherry, walnut, and several imported woods, for inside finish.

Such a wide variety of steam and electric cars for both freight and passenger purposes are built that the car-building shops furnish one of the best markets for many kinds of lumber. Illinois and Pennsylvania are far in the lead in car construction; while much car-building is done in New York, Indiana, Ohio, Missouri, and Virginia.

TABLE 19

CAR CONSTRUCTION

(Annual lumber consumption, 1,070 million board feet)

Woods Used	Per Cent
Yellow Pine	54
Oak	24
Douglas Fir	7
White Pine	6
Yellow Poplar	3
Ash	1
Hemlock	1
Other Woods	4
Total	100

6. Vehicles.—The making of vehicles and vehicle parts is an important industry in many of the Central and Eastern states, though having been revolutionized in recent years by the growth in popularity of the automobile. With the change in conditions many manufacturers of horse drawn vehicles turned to making automobile bodies. The more southerly

states of the group, particularly Arkansas, Kentucky, and Tennessee, furnish the bulk of the raw material; while in Indiana, Ohio, Michigan, Illinois, Wisconsin, Pennsylvania, and New York, are located many large vehicle factories.

Many woods find some use in vehicle construction; but hickory and oak compete closely for the lead, and, taken together, supply over 60 per cent of the raw material. Hickory is used most largely for spokes and rims of wheels, for gear parts, and for felloes, hubs, axles, hounds, and bolsters. Wagon hubs are made of elm and birch; and—in addition to hickory and oak—hard maple, white ash, beech, and other hard, strong woods are used for gear parts and auto body frames. Yellow poplar has been much used for the bodies of carriages, delivery wagons, and automobiles, since it can be obtained in large, clear sizes, works well, and takes paint and polishes easily. Wagon-box boards are largely made from cottonwood, red gum, basswood, and yellow poplar. Bottoms are made of longleaf and shortleaf pine, and also of maple, gum, and oak. Ash is used for frames; while osage orange is used for felloes, especially in the Southwest, where, under severe climatic conditions, the ordinary woods shrink too much.

The proportion of the total consumption of wood for vehicles, including automobiles, contributed by the more important species, is estimated to be as shown in Table 20.

TABLE 20

VEHICLES

(Annual wood consumption, 850 million board feet)

Woods Used	Per Cent
Maple	22
Hickory	21
Oak	16
Elm	15
Birch	7
Ash	6
Red Gum	4
Yellow Poplar	3
Other Woods	6
Total	100

7. Woodenware, Novelties, etc.—The manufacture of woodenware, novelties, and similar articles requires more than 340 million feet of wood annually, of which ash, basswood, and white pine supply nearly equal parts, with the balance contributed by over fifty other species.

TABLE 21

WOODENWARE, NOVELTIES, ETC.

(Annual wood consumption, 340 million board feet)

Woods Used	Per Cent
Ash	15
Basswood	14
White Pine	12
Maple	9
Birch	7
Spruce	7
Chestnut	5
Yellow Pine	5
Elm	4
Beech	3
Cottonwood	3
Cypress	2
Red Gum	2
Oak	2
Yellow Poplar	2
Cedar	2
Tupelo	1
Other Woods	5
Total	100

Much of the material for woodenware goes to the factory in log form, without passing through the sawmill. Wooden pie and picnic plates, butter trays, and dishes are largely made from rotary cut maple, beech, and birch veneers. Many more substantial kinds of woodenware are turned on lathes, among which are dishes, bowls, platters, and trays made from basswood, cottonwood, and maple. Butter tubs are made of ash; butter paddles and trays of ash and beech; bread-boards of basswood, cottonwood, white cedar, silver maple, and birch.

Pails, buckets, and small tubs make up no small proportion of the woodenware output, and they often have white pine staves. Hoops for these articles are made from elm, ash, birch, and red oak. Peck, half-peck, bushel, and half-bushel measures are commonly made with bodies of oak, birch, maple, or white pine, and bottoms of white pine, cottonwood, basswood, or ash.

Novelties include wooden candlesticks, pin trays, paper weights, etc., and are frequently made of the higher-grade and more expensive native and imported woods.

Wisconsin produces the most woodenware of any State, with New York ranking second; while Michigan, Illinois, Minnesota, and Pennsylvania supply many articles of this class.

8. Agricultural Implements.—Notwithstanding a greatly increased use of iron and steel in the manufacture of agricultural implements, such as plows, harrows, cultivators, drills, planters, threshing machines, rakes, and other articles, more than 270 million feet of lumber is annually used in this industry. Yellow pine supplies over 30 per cent of the lumber required for agricultural implements; oak, more than 20 per cent; and maple, 15 per cent, with relatively small quantities of cottonwood, yellow poplar, red gum, ash, hickory, white pine, basswood, elm, beech, birch, and nearly twenty other species.

Longleaf pine is used in agricultural implements where strength but not necessarily toughness is required. Oak finds a large use for plow beams and handles; beech, hickory, and oak, for neck-yokes and single trees; while cottonwood, yellow poplar, red gum, white elm, beech, tupelo, cypress, and Douglas fir are used for seeding and drill boxes. Douglas fir and longleaf pine are also used for poles and tongues of agricultural implements.

Illinois is by far the most important State in the manufacture of agricultural implements, while next in order are Ohio, New York, Indiana, Michigan, and Wisconsin.

TABLE 22

AGRICULTURAL IMPLEMENTS

(Annual lumber consumption, 270 million board feet)

Woods Used	Per Cent
Yellow Pine	31
Oak	22
Maple	15
Cottonwood	5
Yellow Poplar	4
Red Gum	4
Ash	3
Hickory	3
White Pine	3
Basswood	2
Elm	2
Beech	2
Birch	1
Other Woods	3
Total	100

9. Handles.—Handle manufacture is nearly as important as agricultural implement making in regard to the quantity of wood required; and hickory supplies more than two-fifths of all the handle material. Next to hickory, ash—especially white ash—furnishes some 23 per cent of the handle wood; and maple, 15 per cent; while beech, oak, and birch are important handle woods for certain purposes.

TABLE 23

HANDLES

(Annual wood consumption, 250 million board feet)

Woods Used	Per Cent
Hickory	43
Ash	23
Maple	15
Beech	6
Oak	4
Birch	4
Red Gum	2
Elm	1
Other Woods	2
Total	100

Hoe, rake, spade, shovel, and fork handles are chiefly made of ash; sledge and ax handles, of hickory; broom handles, most largely of maple, beech, and birch; cant-hook handles, of hickory and hard maple; pump handles, of oak, ash, and maple; and handles for wire stretchers, of white and rock elm.

Small handles for chisels, mallets, planes, awls, saws, etc., are often made from apple wood; while the handles for many small articles in which good appearance is desired are made from boxwood, walnut, mahogany, rosewood, and ebony.

Like the vehicle woods, much of the handle material is produced in the South, and worked up in the North. Arkansas and Kentucky supply large amounts of hickory for handles; but they also rank first and third respectively in the production of finished handles. Many handles are made in Michigan, Ohio, Indiana, and Illinois.

10. Musical Instruments.—The manufacture of musical instruments consumes a large amount of both native and foreign woods. Of the native woods, nearly equal quantities of maple, yellow poplar, and chestnut are used; while spruce, oak, elm, birch, basswood, white pine, and red gum are largely drawn upon.

The manufacture of phonograph cabinets has developed into an important line, utilization of mahogany, walnut, gum, and oak, largely in veneers, being quite heavy. In a number of instances entire furniture factories are now sole producers of phonograph cabinets.

The making of cases for pianos and organs requires a great deal of lumber, maple being used to give strength, yellow poplar and chestnut as the backing for veneer, spruce for sounding boards, the finer hardwoods and imported woods for the keys, red gum and maple for action parts, birch for key rails and hammers, and beech and elm for backs. Many woods are used to give a varied and beautiful effect in the smaller musical instruments. Spanish cedar is used for the necks of banjos, guitars, and mandolins; boxwood, for inlay work; mahogany, bird's-eye maple, rosewood, yellow poplar, birch, walnut, and oak, for drums; bird's-eye and curly maple, and rosewood, for harp boxes, etc.

Illinois uses more wood than any other state for the manufacture of musical instruments, and New York ranks second;

while Massachusetts, New Jersey, and Michigan are large consumers of material for this purpose.

TABLE 24

Musical Instruments

(Annual lumber consumption, 220 million board feet)

Woods Used	Per Cent
Maple	17
Yellow Poplar	16
Chestnut	15
Spruce	11
Oak	8
Elm	6
Birch	5
Basswood	4
White Pine	3
Red Gum	3
Mahogany	3
Black Walnut	2
Beech	2
Ash	1
Other Woods	4
Total	100

11. Tanks and Silos.—Wooden tanks and silos require straight-grained, easily-worked, durable material which can be obtained in good sizes and which will not impart any objectionable taste to the contents. The woods most largely used for these purposes are Douglas fir, yellow pine, cypress, white pine, spruce, redwood, and larch or tamarack. Douglas fir and yellow pine are used to a very large extent for silos, because of their abundance; while, to a lesser extent, silos are made from cypress, tamarack, redwood, and hemlock. Tanks and vats for holding oil, water, chemicals and acids are largely made from cypress and redwood.

In the manufacture of finished tanks and silos, Indiana has the leading place, followed closely by Illinois, Iowa, Michigan, and New York. However, silos are not necessarily factory products, since material for them is produced at sawmills and sold through lumber dealers in the localities where silos are erected. For this reason, the figures given in Table 25 are less than the total lumber consumption for tanks and silos.

TABLE 25

TANKS AND SILOS

(Annual lumber consumption 190 million board feet)

Woods Used	Per Cent
Douglas Fir	40
Yellow Pine	18
Cypress	16
White Pine	8
Spruce	5
Larch	4
Redwood	4
Oak	2
Cedar	2
Other Woods	1
Total	100

12. Ship and Boat Building.—The ship and boat industry in the United States normally consumes 170 million feet of lumber annually, of which yellow pine supplies one-third, Douglas fir about one-fifth, and oak about one-sixth. Important woods in this industry are also white pine, ash, spruce, cedar, and cypress; while nearly forty other woods are used to a less extent, including such imported species as mahogany, teak, prima vera, Spanish cedar, Circassian walnut, balsam, lignum vitae, padouk, and rosewood.

TABLE 26

SHIP AND BOAT BUILDING

(Annual lumber consumption, 170 million board feet)

Woods Used	Per Cent
Yellow Pine	33
Douglas Fir	22
Oak	16
White Pine	7
Ash	4
Spruce	4
Cedar	4
Cypress	3
Hemlock	2
Other Woods	5
Total	100

Yellow pine and Douglas fir are the most important shipbuilding woods because of their strength and their availability in large structural sizes. Both longleaf pine and Douglas fir are used for planking, spars, decking, keels, keel-blocks, rails, guards and the like. Cypress, white pine, oak, yellow pine, and Douglas fir are also used for inside finish, as well as for ceiling and decking; while numerous hardwoods and imported woods are used for inside finish. Teak is used for armor backing and decking; and balsa, or corkwood, for life preservers.

On the Pacific coast, Douglas fir, Port Orford cedar, redwood, and Sitka spruce find a large use in ship and boat building; while in Maine and some of the Eastern states, the manufacture of high-grade pleasure canoes has assumed large proportions, these canoes being often made with white cedar ribs, planking of Western red cedar, gunwales of spruce or mahogany, thwarts of birch or maple, and seats of birch, maple, or ash.

New York is the largest ship and boat building state, due to the Brooklyn Navy Yard and barge building yards. Pennsylvania takes second rank because of its large shipbuilding plants; while California, Oregon, New Jersey, Virginia, and Maine are also large producers of ships and boats.

13. Caskets and Coffins.—About 130 million feet of lumber are used annually in the manufacture of caskets and coffins, of which chestnut supplies 30 per cent, white pine 22 per cent, and cypress 13 per cent, the balance being made up by nearly thirty other woods.

Chestnut and white pine are most largely used in the manufacture of cloth-covered caskets and coffins. Chestnut is also much used as the backing for a veneer of more expensive woods of ornamental appearance. The exterior often consists of mahogany, yellow poplar, white oak, red oak, or birch. Cypress, cedar, and redwood are used because of their resistance to decay; while white pine, shortleaf pine, and yellow poplar are common woods for outer boxes and shipping cases.

In the manufacture of caskets and coffins, New York ranks first, followed by Pennsylvania, Indiana, Tennessee, Ohio, Missouri, and Illinois.

TABLE 27

CASKETS AND COFFINS

(Annual lumber consumption, 130 million board feet)

Woods Used	Per Cent
Chestnut	30
White Pine	22
Cypress	13
Yellow Pine	8
Yellow Poplar	6
Oak	5
Red Gum	5
Cedar	4
Basswood	2
Hemlock	1
Other Woods	4
Total	100

14. Refrigerators and Kitchen Cabinets.—Nearly 20 species of wood are used in the manufacture of refrigerators and kitchen cabinets; but oak supplies 23 per cent of the total, ash 14 per cent, and red gum 10 per cent. Other woods used to a considerable extent for this purpose are elm, white and yellow pine, hemlock, maple, yellow poplar, spruce, basswood, cottonwood, and birch.

Woods for refrigerators and kitchen cabinets must meet a wide variety of requirements. The outside finish must look well, and here the usual cabinet woods are employed. Strong, stiff material for frames is supplied by ash, hemlock, and short-leaf pine; elm and beech stand up well under dampness, and scour well when washed. It is also essential that, in certain places, woods shall be used which impart no odors to food; for this purpose spruce, ash, elm, maple, basswood, cottonwood, and cypress are satisfactory. Ice-boxes are often made of spruce, refrigerator backs of white pine, and ice cream freezers of redwood.

In the manufacture of refrigerators and kitchen cabinets, Michigan ranks first, and Indiana, second, followed by New York, Wisconsin, and Illinois.

TABLE 28

REFRIGERATORS AND KITCHEN CABINETS

(Annual lumber consumption, 120 million board feet)

Woods Used	Per Cent
Oak	23
Ash	14
Red Gum	10
Elm	9
White Pine	6
Yellow Pine	6
Hemlock	5
Maple	5
Yellow Poplar	4
Spruce	4
Basswood	4
Cottonwood	3
Birch	3
Cypress	1
Chestnut	1
Other Woods	2
Total	100

15. Excelsior.—Excelsior finds a large use for packing mattresses, and upholstering. It is made in a number of grades based on quality and fineness; and the best requires a wood which, in addition to working easily, gives a tough, flexible product. The finest grade—called "wood wool"—has a strand less than 1/100 of an inch in thickness.

TABLE 29

EXCELSIOR

(Annual wood consumption, 85 million board feet)

Woods Used	Per Cent
Cottonwood	54
Yellow Pine	15
Basswood	14
Willow	4
Red Gum	3
Maple	3
White Pine	2
Yellow Poplar	2
Buckeye	1
Other Woods	2
Total	100

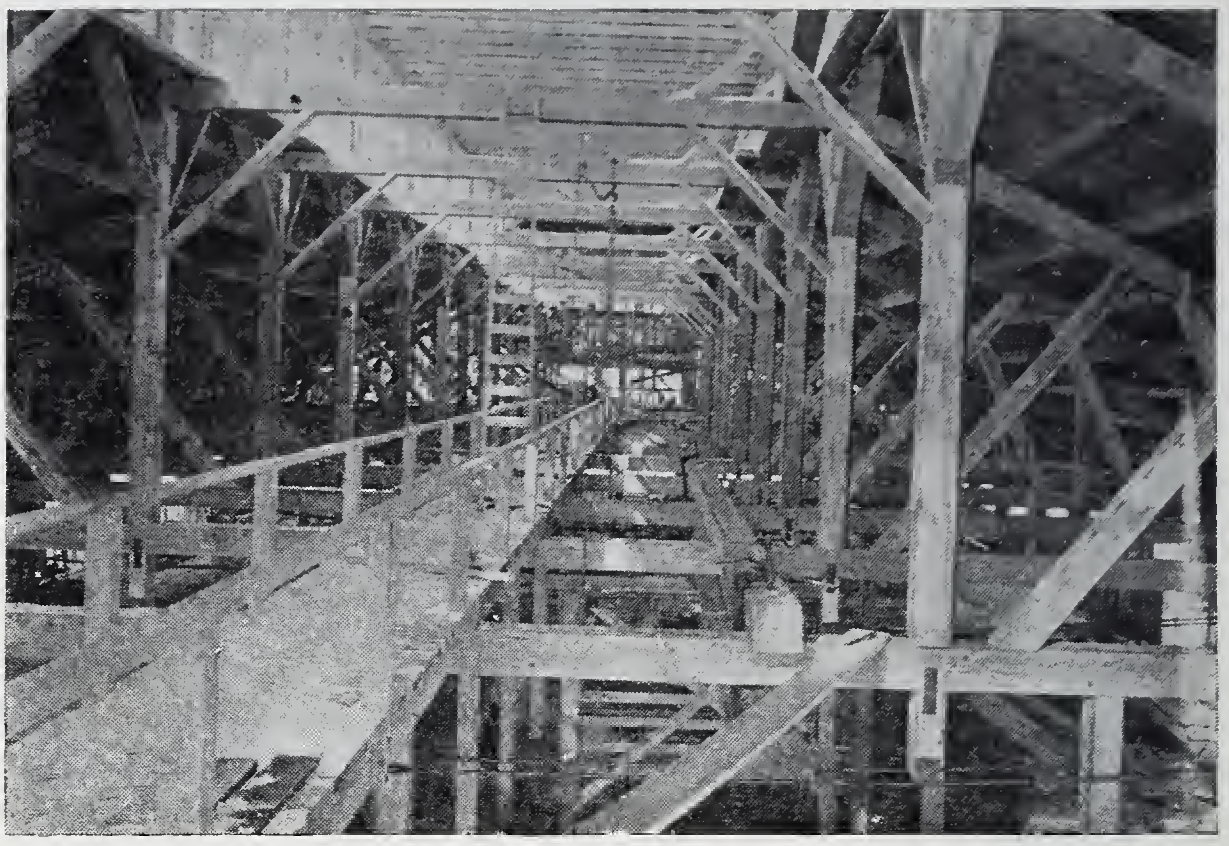

Fig. 68.—Interior of a Sawmill, Showing Method of Timber Construction.

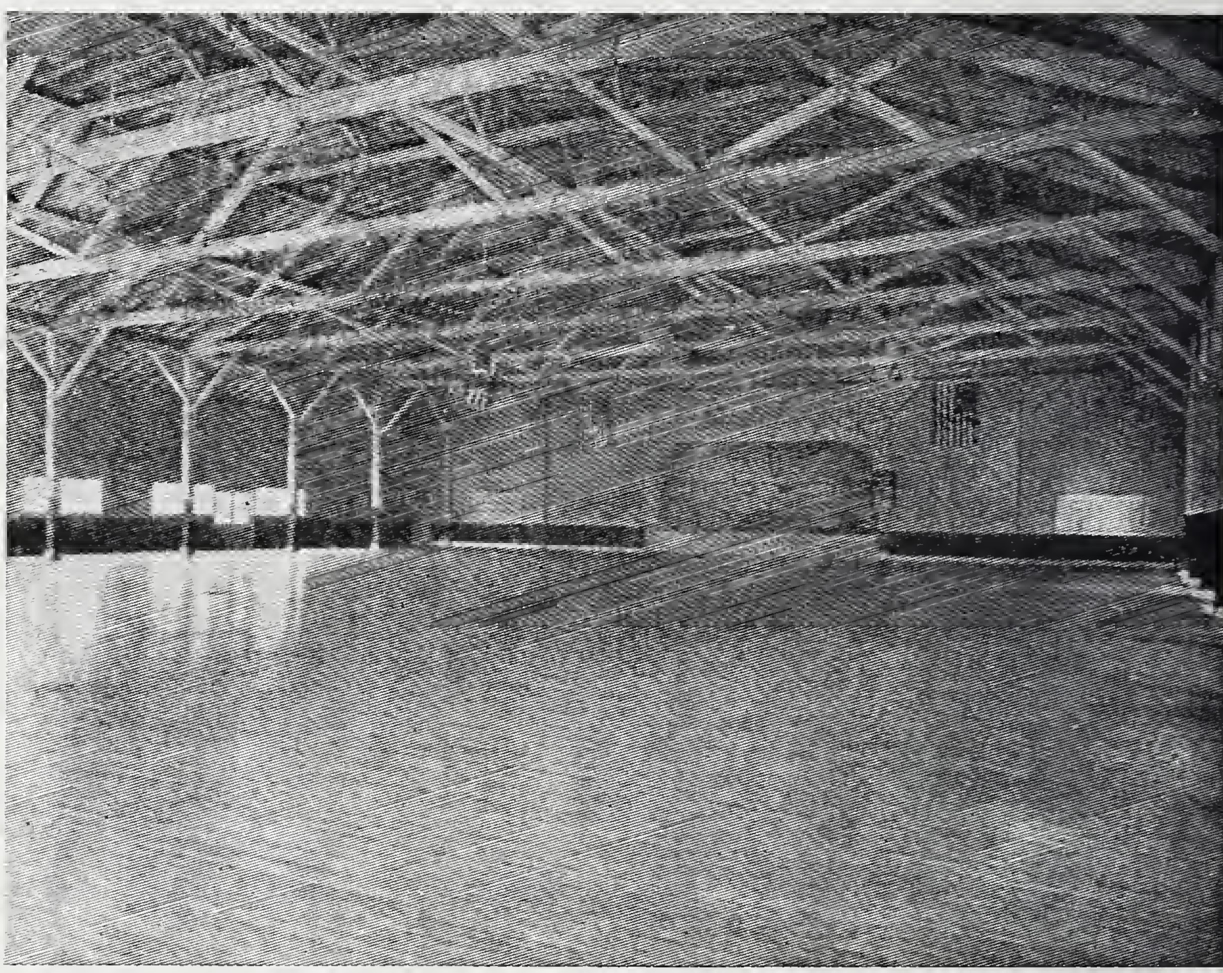

Fig. 69.—Maple Flooring in a Dance Hall.

WOOD CONSTRUCTION

The true poplars, including the various aspens and cottonwoods, supply more than half of the excelsior manufactured in the United States. Basswood and yellow poplar give a product of similar character, while coarser grades are made from yellow pine and several other woods. Among the States in which excelsior is most largely produced, are New York, Kentucky, New Hampshire, Wisconsin, and Washington.

16. Matches and Toothpicks.—Although put into one table in the statistical reports, matches and toothpicks are by no means made from the same woods. White pine has long been a standard match material, and basswood is used to some extent for this purpose in the eastern factories. On the Pacific coast, sugar pine and Port Orford cedar are used for match sticks; while in Virginia yellow poplar and soft maple are also used. Spruce is employed for the making of match cases. Matches are made chiefly in Ohio, Michigan, New York, Massachusetts and Pennsylvania.

Toothpicks are made almost exclusively from birch and maple and are produced in Maine and Michigan.

TABLE 30

MATCHES AND TOOTHPICKS

(Annual wood consumption, 72 million board feet)

Woods Used	Per Cent
White Pine	66
Sugar Pine	20
Basswood	7
Birch	4
Maple	1
Spruce	1
Other Woods	1
Total	100

17. Laundry Appliances.—Laundry appliances include washing machines, washboards, ironing boards, clothes wringers, mangles, tubs, clothespins, and similar articles. Cypress and maple compete closely for the lead in the manufacture of laundry appliances, while nearly equal quantities of beech and cottonwood are required. More than twenty other woods contribute to the total of 68 million feet of lum-

ber annually consumed in this industry. Metal construction is fast taking the place of wood, and in many household laundry appliances little or no wood is now used.

Cottonwood, basswood, and Sitka spruce are much used for washboards. Frames of ironing boards are often made of maple; and the tops, of cypress, cottonwood, spruce, basswood, and white pine. Wooden mangles are usually made of elm, beech, or maple; and wooden tubs frequently have cypress staves. Laundry machine construction uses cypress, maple, basswood, yellow poplar, and red and white oak. Clothespins are most largely made of basswood, beech, and maple, and also to some extent of birch, elm, and ash.

In manufacture of laundry appliances, Michigan has a large lead, with Pennsylvania, Illinois, Iowa, and New York ranking next in importance.

TABLE 31

LAUNDRY APPLIANCES

(Annual lumber consumption, 68 million board feet)

Woods Used	Per Cent
Cypress	19
Maple	18
Beech	12
Cottonwood	10
Basswood	6
Cedar	6
Birch	5
Tupelo	5
Red Gum	4
White Pine	4
Spruce	3
Yellow Pine	2
Elm	2
Hemlock	2
Other Woods	2
Total	100

18. Shade and Map Rollers.—Nearly four-fifths of all shade and map rollers are made from white pine; and one-seventh, from spruce and other softwoods. Such hardwoods as are credited to this industry are used chiefly for curtain poles and trim.

TABLE 32

SHADE AND MAP ROLLERS

(Annual lumber consumption, 67 million board feet)

Woods Used	Per Cent
White Pine	78
Spruce	9
Douglas Fir	4
Red Gum	3
Yellow Pine	1
Tupelo	1
Maple	1
Other Woods	3
Total	100

19. Paving Materials and Conduits.—The manufacture of paving materials and conduits of wood which is given a chemical treatment to prevent decay, is one of the more recently developed industries; but it has already reached a considerable size, requiring about 65 million feet of lumber annually. As is brought out in the discussion of wood block pavements, yellow pine is by far the most largely used wood for this purpose; but larch or tamarack, Douglas fir, Norway pine, redwood, and tupelo are also used, the latter two more especially for conduits to carry underground telegraph or telephone lines. These materials are prepared wherever creosoting plants may be located, of which there are now nearly 150 in the United States, as shown by the map in Fig. 42, page 110.

TABLE 33

PAVING MATERIALS AND CONDUITS

(Annual lumber consumption, 65 million board feet)

Woods Used	Per Cent
Yellow Pine	86
Larch	5
Douglas Fir	5
Redwood	2
Other Woods	2
Total	100

20. Trunks and Valises.—The manufacture of trunks and valises annually consumes about 64 million feet of twenty-four different woods, of which basswood supplies 28 per cent, yellow pine 20 per cent, and white pine 10 per cent.

Trunks and valises are usually made from softwoods which offer a desirable combination of light weight and strength, or from veneer of hardwoods, in which strength can be secured without much weight. Trunk slats are generally of maple, beech, or elm; and where strength is an important property. Trunk trays are largely made from basswood and yellow pine; while the box of the trunk is either of thin lumber with some kind of outside covering, or, in the better grades, of built-up veneer, which gives much strength and resistance to hard knocks. Douglas fir is largely used in the west in the manufacture of trunks.

Trunks and valises are largely made in Virginia, Michigan, Wisconsin, Missouri, Pennsylvania, and Ohio.

TABLE 34

TRUNKS AND VALISES

(Annual lumber consumption, 64 million board feet)

Woods Used	Per Cent
Basswood	28
Yellow Pine	18
White Pine	10
Hemlock	9
Elm	9
Maple	7
Yellow Poplar	4
Cottonwood	3
Red Gum	2
Spruce	2
Cypress	2
Douglas Fir	2
Other Woods	4
Total	100

21. Machine Construction.—Under this heading are grouped such machines as steam shovels, cranes, hoists, well drills, dredges, crushers, presses, etc., in which much of the wood used

must possess strength, toughness, and durability. Yellow pine supplies one-third of the wood required for machine construction; cypress, 23 per cent; and oak, 12 per cent; while nearly thirty other woods are used in smaller amounts.

The manufacture of machinery of this character is scattered over a number of states, and not so centralized as are many other industries. Among the states in which machine construction attains considerable magnitude, however, are Illinois, Pennsylvania, Wisconsin, and Ohio.

TABLE 35

MACHINE CONSTRUCTION

(Annual lumber consumption, 59 million board feet)

Woods Used	Per Cent
Yellow Pine	32
Cypress	23
Oak	12
White Pine	8
Maple	5
Hemlock	5
Yellow Poplar	3
Ash	2
Basswood	2
Hickory	2
Douglas Fir	1
Elm	1
Spruce	1
Beech	1
Other Woods	2
Total	100

22. Boot and Shoe Findings.—By boot and shoe findings are chiefly meant lasts, last blocks, shoe forms, shoe trees, shoe pegs, and wooden heels. The material for these articles goes to the factory in log or bolt form; and the amount annually required is equivalent to about 56 million board feet of lumber. That the manufacture of these small articles is after all no mean industry is proved by the fact that the amount of wood used for boot and shoe findings in Maine is normally greater than that used by the shipyards and boat and canoe builders of that State.

Shoe lasts are made very largely from maple; while basswood is used for forms or fillers. A small amount of birch is also used for lasts, and shoe pegs and shanks are made of it. Wooden heels are made of maple.

The manufacture of lasts is one of the most painstaking operations in the wood-using industries. The last blocks are air dried for a long time, and then very slowly dried by artificial heat before they are turned to the finished pattern. Maple is preferred for lasts, because it is hard, smooth, and tough, takes a high polish, does not warp or shrink, and stands up well under the severe wear to which lasts are subjected.

The most important States in the manufacture of boot and shoe findings, are New York, Michigan, Massachusetts, and Maine.

TABLE 36

BOOT AND SHOE FINDINGS

(Annual wood consumption, 56 million board feet)

Woods Used	Per Cent
Maple	82
Birch	11
Basswood	5
Beech	1
Other Woods	1
Total	100

23. Picture Frames and Moldings.—Although small articles in themselves, the manufacture of picture frames and moldings in the United States annually consumes about 55 million feet of lumber of more than thirty species. Of this total, basswood, oak, and red gum supply two-thirds; and of the remainder, white and yellow pine, birch, yellow poplar, chestnut, and beech are the more important woods.

Oak is largely used for picture frames because of its ornamental value; white pine, basswood, and yellow poplar, because they are light, easily worked, and take finishes and enamel well; while such woods as birch, red gum, mahogany, walnut, rosewood, etc., are used for hand mirrors, where both facing and backing must present an ornamental appearance.

Illinois uses by far the largest quantity of wood of any State in the manufacture of picture frames and moldings; while other important States in the production of these articles are New York, Maryland, Michigan, Indiana, and Ohio.

TABLE 37

PICTURE FRAMES AND MOLDINGS

(Annual lumber consumption, 55 million board feet)

Woods Used	Per Cent
Basswood	31
Oak	25
Red Gum	12
White Pine	9
Yellow Pine	8
Birch	5
Yellow Poplar	3
Chestnut	2
Beech	2
Other Woods	3
Total	100

24. Shuttles, Spools, and Bobbins.—The manufacture of shuttles, spools, and bobbins requires practically as much wood as do picture frames and moldings. It constitutes an important industry in many states, and especially in Maine. Spools are made chiefly from paper birch; and, in addition to the quantity used at home, several million feet of spool stock are annually exported from Maine to Scotland. Only birch is used in the manufacture of small, one-piece spools. Three-piece spools are also made of yellow poplar and red gum. Bobbins are made from maple, birch, and beech; while shuttles—which, for factory purposes, must be exceedingly resistant to wear, are made almost entirely from dogwood and persimmon. These woods are very dense, hard, and strong, and become extremely smooth with wear.

Maine uses nearly one-third of all the material consumed in the United States for shuttles, spools, and bobbins; New Hampshire, about one-sixth; while Massachusetts, South Carolina, and Rhode Island produces the articles in lesser quantities.

FIG. 70.—Interior of a Chair Factory in North Carolina.

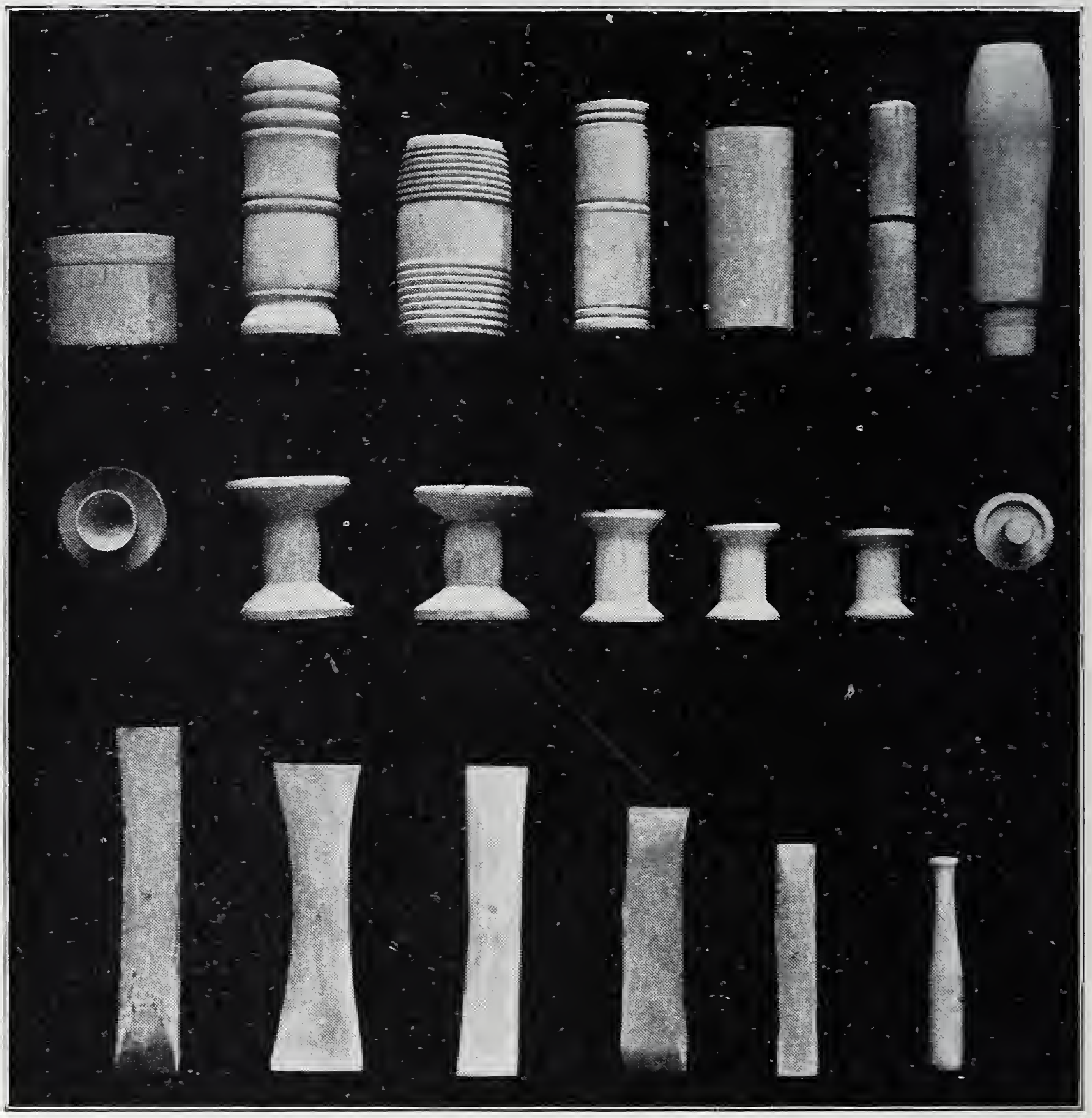

FIG. 71.—Boxes, Spools, Shoe Shanks, and Other Articles Made from Paper Birch.

Tennessee is perhaps the most important State in supplying the dogwood and persimmon used in the northern factories for the manufacture of shuttles.

TABLE 38

SHUTTLES, SPOOLS, AND BOBBINS

(Annual wood consumption, 55 million board feet)

Woods Used	Per Cent
Birch	51
Maple	21
Dogwood	11
Beech	5
Persimmon	4
Basswood	3
Hickory	1
Yellow Poplar	1
Other Woods	3
Total	100

25. Tobacco Boxes.—The standard material for cigar boxes is Spanish cedar. The highest-grade boxes are made entirely of this wood, while the cheaper boxes often have a veneer of Spanish cedar laid over a backing of tupelo, yellow poplar, red gum, or some cheaper wood. These latter woods are sometimes stained to imitate Spanish cedar without the application of the more costly veneer. In addition to the woods shown in

TABLE 39

TOBACCO BOXES

(Annual lumber consumption, 54 million board feet)

Woods Used	Per Cent
Spanish Cedar	47
Tupelo	16
Yellow Poplar	12
Red Gum	11
Basswood	7
Elm	3
Cypress	2
Other Woods	2
Total	100

Table 39, smaller quantities of oak, cedar, sycamore, white pine, mahogany, magnolia, redwood, African cedar, maple, cottonwood, Circassian walnut, and rosewood are also used.

Containers for plug, smoking, and chewing tobacco are largely made from sycamore and red gum, usually in the form of three-ply veneer.

Among the more prominent states in the manufacture of cigar and tobacco boxes, are Florida, New York, Pennsylvania, Missouri, Wisconsin, Ohio, and Alabama.

26. Sewing Machines.—The manufacture of sewing machine cabinets and tops annually requires about 51 million feet of lumber, of which oak and red gum each supply nearly one-third, and yellow poplar and black walnut each a little more than one-eighth, the balance being made up of tupelo, chestnut, cottonwood, maple, basswood, birch, sycamore, mahogany, yellow pine, and redwood.

Tops of sewing machines are usually made of hardwood veneer such as oak or walnut, or of other woods stained to imitate mahogany. In addition to its use for veneered tops, red gum is used in sewing machine parts and for veneer backing as is also tupelo. The sewing machine cabinet industry is rather local, and centered most largely in Indiana and Illinois.

TABLE 40

SEWING MACHINES

(Annual lumber consumption, ~~60~~ 51 million board feet)

Woods Used	Per Cent
Oak	32
Red Gum	32
Yellow Poplar	13
Black Walnut	13
Tupelo	7
Chestnut	1
Other Woods	2
Total	100

27. Pumps and Wood Pipe.—While many more pumps and parts of pumps are made of other materials than was once the case, the pump-making industry consumes a considerable quan-

tity of wood in the form of piping, tubing, rods, handles, platforms, buckets, cylinders, etc.

TABLE 41

PUMPS AND WOOD PIPE

(Annual lumber consumption, 48 million board feet)

Woods Used	Per Cent
Douglas Fir	38
White Pine	22
Redwood	16
Red Gum	6
Cypress	4
Yellow Poplar	3
Maple	3
Ash	2
Hickory	2
Oak	1
Tupelo	1
Larch	1
Other Woods	1
Total	100

White pine is largely used for piping, tubing, siding, curbing, and covering. Well buckets are made of maple, ash, beech, and oak; pump handles and rods, of oak, ash, and beech; water pipes, of yellow poplar, maple, and white pine; and platforms, of cypress. Shortleaf pine and cypress are used for boxes for chain and bucket pumps; tupelo, for pump stocks; and short and longleaf pine, for pump poles. In the west, Douglas fir and redwood are largely used for pumps, and more especially for wood pipe, where some exceptionally large pipes of this character carry city water supplies.

28. Automobiles.—Statistics of the consumption of wood in automobile manufacture are by no means complete, since, in many cases, the reports do not distinguish between the manufacture of automobiles and that of other vehicles. Moreover, conditions in the automobile field have changed so rapidly and so many bodies are now made of metal that reliable information upon the consumption of lumber by this industry is not available.

For these reasons, Table 42, which in the first and second editions of this book gave statistics upon the woods used for automobiles, is omitted from the present edition.

Paneling of the earlier cars was largely of wood veneer, which was supplanted by pressed metal. The increasing output of closed cars has greatly enlarged the use of lumber for body frames and finish.

Automobile manufacturers demand both high and low grades of lumber. Maple, birch and ash are employed for frames; hickory, for wheels; elm, for the interior of bodies; yellow poplar, black and Circassian walnut, birch, and red gum, for the finish of tops and bodies. The wood finisher employs his highest art in giving a fine appearance to automobiles, and he must have good materials with which to work.

It is said automobile manufacturers are now buying annually 500 million feet of hardwoods, chiefly maple, elm, birch and ash, besides large quantities of softwoods for crating purposes and that the hickory required for auto wheels amounts to an average of 33 board feet for each set of wheels produced.

29. Pulleys and Conveyors.—The manufacture of pulleys and conveyors requires about 31 million feet of wood annually, of which red gum supplies more than one-half, and oak one-fifth, the balance being made up of some twenty species, of which maple, birch, beech, tupelo, and basswood are the most important.

TABLE 43

PULLEYS AND CONVEYORS

(Annual lumber consumption, 31 million board feet)

Woods Used	Per Cent
Red Gum	55
Oak	20
Maple	7
Beech	6
Birch	2
Tupelo	2
Basswood	2
Ash	1
Yellow Poplar	1
Other Woods	4
Total	100

Pulleys and conveyors are manufactured in many different places; but such statistics as are available indicate that by far the largest proportion of the output comes from Kentucky, with a decidedly smaller amount from Indiana and Michigan.

30. Professional and Scientific Instruments.—The manufacture of professional and scientific instruments of a wide variety requires more than thirty domestic and foreign woods amounting to an annual total of about 30 million feet. Pencils are included, however, in this classification; and for them Southern red cedar is chiefly used, because of its softness, straight, even grain, and good whittling qualities. Maple is largely used in the manufacture of rulers, yard sticks, camera boxes, and other articles. Basswood finds a large use in the making of yard sticks, drafting tables, alphabet blocks, and advertising novelties. Penholders are chiefly made from basswood and

TABLE 44

Professional and Scientific Instruments

(Annual wood consumption, 30 million board feet)

Woods Used	Per Cent
Cedar	57
Maple	13
Basswood	7
Beech	4
Birch	3
Yellow Poplar	3
Hickory	3
Cherry	2
Boxwood	2
White Pine	2
Other Woods	4
Total	100

red gum; level blocks, from cherry; thermometers, from oak; planes, from beech; surveyors' stakes, from oak, longleaf pine, chestnut, and hickory; drafting tables and equipment, from ash, basswood, beech, mahogany, birch, and white pine; and camera boxes and parts, from basswood, beech, butternut,

cypress, hickory, mahogany, spruce, maple, oak, and yellow poplar.

The state of New York is by far the largest producer of professional and scientific instruments. New Jersey comes next; and Michigan, third.

31. Toys.—Basswood and maple supply more than two-fifths of the wood used in toy making, basswood being often used for the bottoms of children's wagons and carts, while the seats and rims are made from maple. Axles, spokes, and rims are made from oak; spokes and frames, from ash; and sled tops, from chestnut. Dominoes and checkers are made from both maple and basswood, while toy blocks are made chiefly from basswood and some yellow poplar. Toy wagons and sleds are also made from birch; doll furniture, from white pine, birch, maple, and beech; doll houses, from birch and basswood; while many turned toys are made from birch.

TABLE 45

TOYS

(Annual lumber consumption, 25 million board feet)

Woods Used	Per Cent
Basswood	30
Maple	14
Beech	11
Birch	11
White Pine	8
Elm	7
Oak	5
Chestnut	3
Ash	3
Yellow Poplar	3
Red Gum	2
Cottonwood	1
Other Woods	2
Total	100

In the manufacture of toys, Pennsylvania is the leading state, followed very closely by Wisconsin, Maine, Michigan, and New York.

32. Sporting and Athletic Goods.—More than 30 different woods contribute to the total of 21 million feet of timber

annually required in the manufacture of sporting and athletic goods. Of this quantity, hickory and maple supply 40 per cent; elm and ash, each 13 per cent; and oak, 10 per cent.

These goods comprise a long list of articles, including baseball bats, bowling balls, dumbbells, fishing rods, golf clubs, Indian clubs, skis, snowshoes, tenpins, tennis rackets and many others. Among other purposes, hickory, maple, beech, and ash are used for baseball bats; elm, for gymnasium goods; and maple, for tenpins. A great deal of oak is used for billiard and pool tables, and rosewood for the exterior finish. Maple is used for billiard cues, with black walnut, ebony, Circassian walnut, and rosewood for the decorative parts. Yellow pine is used in the manufacture of bowling alleys; and also a great deal of maple. Lignum vitae is the preferred wood for bowling balls. Golf clubs are usually made with hickory handles and persimmon heads. Climbing poles may be made of yellow pine; and vaulting poles, of spruce. Altogether, the demands upon the woods used for sporting and athletic goods are many and varied, but the qualities of strength and toughness are the ones most largely required.

In the manufacture of these goods, Michigan holds first place, with New York, Tennessee, and Illinois following in close order.

TABLE 46

SPORTING AND ATHLETIC GOODS

(Annual wood consumption, 21 million board feet)

Woods Used	Per Cent
Hickory	20
Maple	20
Elm	13
Ash	13
Oak	10
Birch	4
Yellow Poplar	4
Yellow Pine	4
White Pine	3
Basswood	1
Other Woods	8
Total	100

33. Patterns and Flasks.—The reports group the woods used for patterns and flasks, although they really have no property in common, and very different grades of material are required for the two purposes. For pattern making, soft, even-grained, easily worked woods which swell and shrink very little are required; while, for the foundry flasks which hold the sand and patterns, almost any wood will do.

By far the larger proportion of patterns are made from white pine, although, for specially fine castings—in which it is important to have durable patterns that can be used many times without wear or swelling and shrinking—expensive woods like mahogany and cherry are used. Because of its resistance to wear, white oak is also employed to some extent for patterns. Flasks are made from yellow pine, white pine, hemlock, redwood, and a number of other woods.

In the manufacture of patterns and flasks, Pennsylvania seems to have a decided lead; while New York, New Jersey and Ohio use more wood for these purposes than any other State except Pennsylvania.

TABLE 47

PATTERNS AND FLASKS

(Annual lumber consumption, 20 million board feet)

Woods Used	Per Cent
White Pine	75
Yellow Pine	8
Redwood	4
Hemlock	2
Spruce	2
Yellow Poplar	1
Sugar Pine	1
Mahogany	1
Cedar	1
Other Woods	5
Total	100

34. Bungs and Faucets.—The manufacture of such apparently insignificant articles as bungs and faucets annually re-

quires more than 18 million board feet of wood, of which yellow poplar supplies 85 per cent. This wood is preferred because it is straight-grained, soft, and easily worked, and because it contracts and expands evenly. The even expansion of the bung is what causes it to fit tightly and prevent leakage.

By far the larger proportion of the bungs manufactured are produced in Ohio, and especially in Cincinnati, although the yellow poplar from which they are made comes mainly from Kentucky, Tennessee, and West Virginia.

TABLE 48

BUNGS AND FAUCETS

(Annual wood consumption, 18 million board feet)

Woods Used	Per Cent
Yellow Poplar	85
Maple	4
Beech	4
Red Gum	2
Birch	1
White Pine	1
Oak	1
Other woods	2
Total	100

35. Plumbers' Woodwork.—For plumbers' woodwork, about the same quantity of wood is required as for bungs and faucets. Under this heading is included the wood used in the manufacture of toilet tanks, seats, bathroom cabinets, and other plumbers' equipment. Oak is the chief wood for these purposes, with birch second, and much smaller quantities of a dozen other woods consumed. For exterior work where a fine appearance is desired, oak is most largely used, together with birch, cherry, and mahogany. Maple and yellow poplar are employed for painted or enameled work; and yellow poplar, chestnut, red gum, and shortleaf pine, for tank backing. Ash is often used for wash-tray frames.

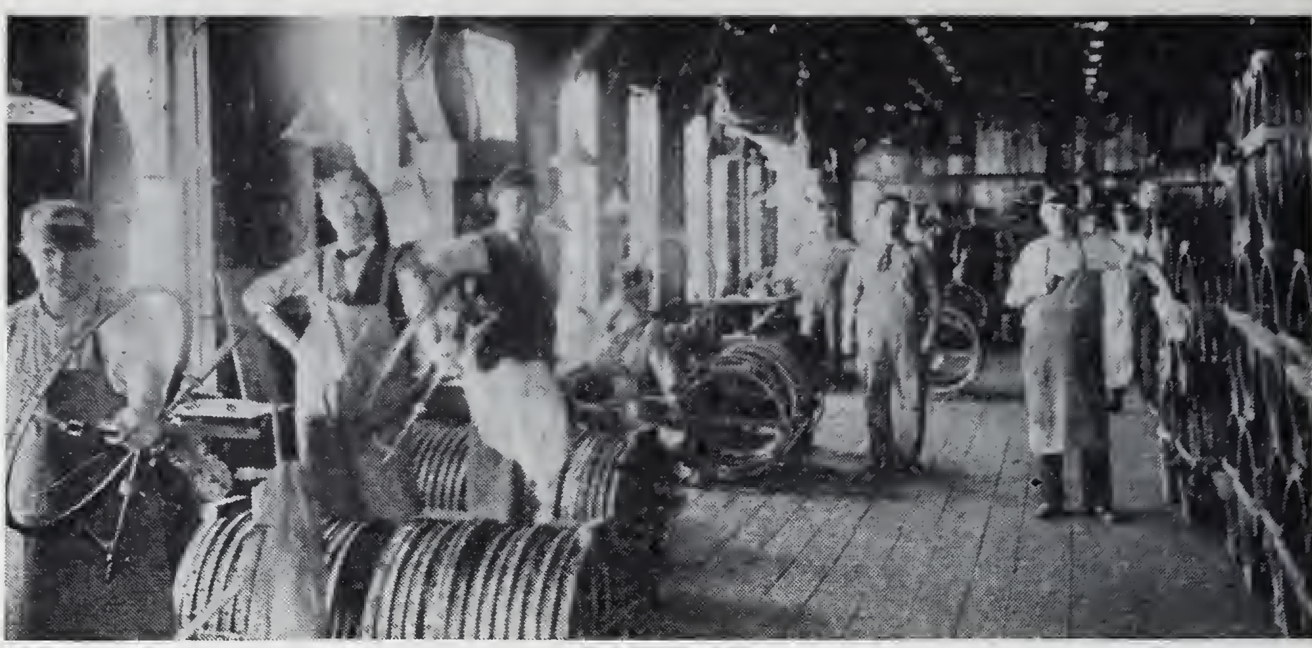

Fig. 72.—Making Bicycle Rims of Hard Maple in a New Hampshire Factory.

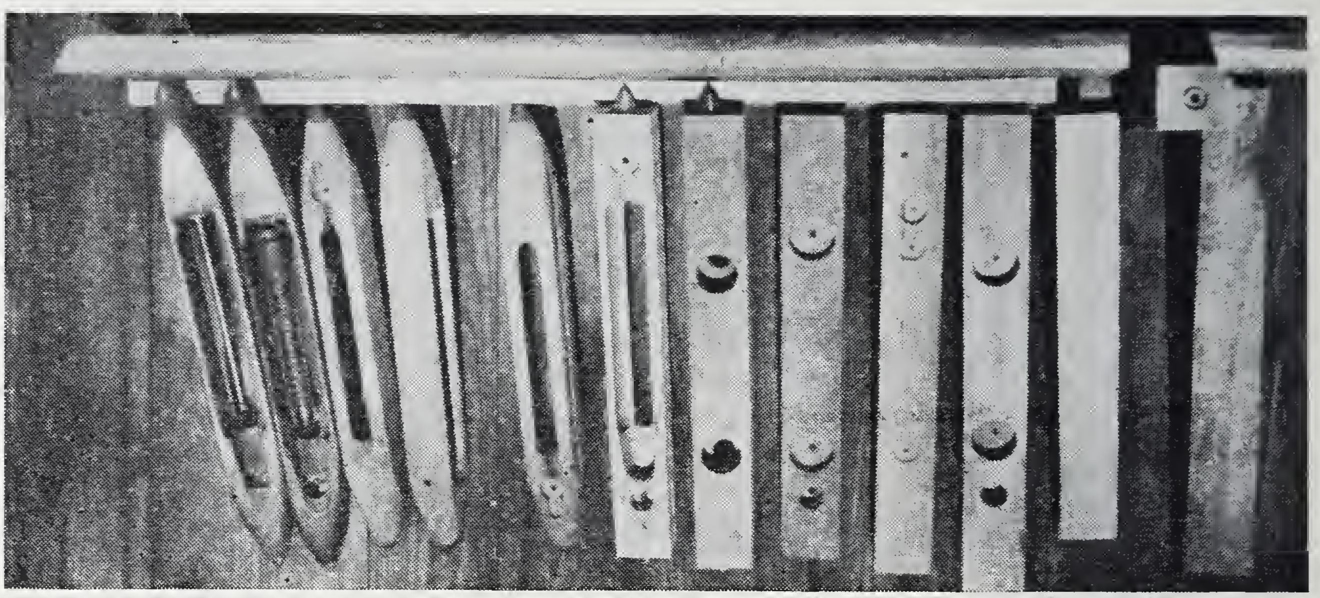

Fig. 73.—Successive Stages in Making Shuttles from Dogwood and Persimmon.

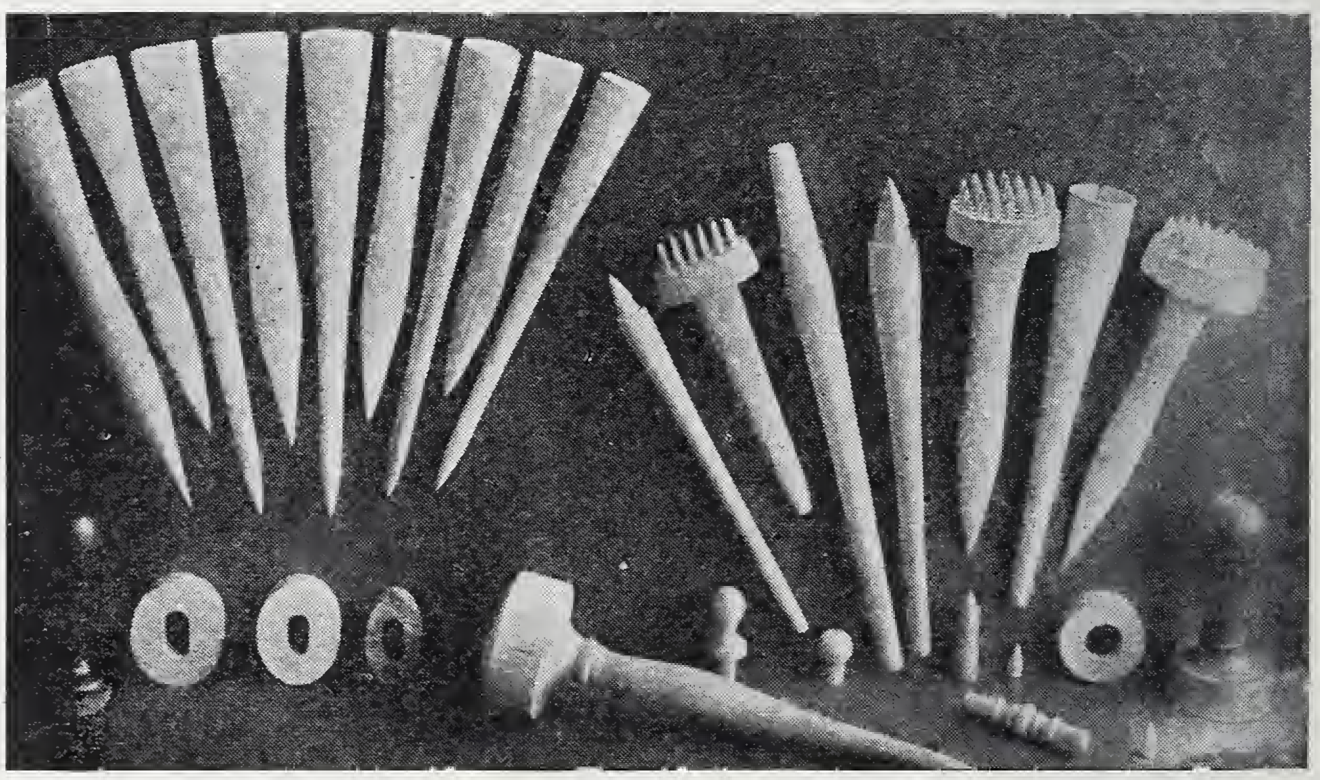

Fig. 74.—Paint-Brush Handles Made from Birch and Maple.

ARTICLES MADE FROM WOOD

TABLE 49

PLUMBER'S WOODWORK

(Annual lumber consumption, 17 million board feet)

Woods Used	Per Cent
Oak	70
Birch	12
Yellow Poplar	4
White Pine	4
Ash	3
Red Gum	2
Maple	2
Yellow Pine	1
Basswood	1
Other Woods	1
Total	100

36. Electrical Machinery and Apparatus.—Oak is the leading wood in the manufacture of electrical machinery and apparatus, while white pine and spruce are also of much importance. The three supply 55 per cent of the annual requirement of about 15 million feet. Many other woods are used in smaller quantity.

Much of the spruce is used in the manufacture of conduits, reels, and spools for wire; while some birch, white pine, yellow poplar, red gum, and basswood are also used for this purpose. Railway signal devices require most of the white cedar and cypress used in this industry, since these woods offer good resistance to the elements. Rough telephone boxes are made of hemlock, oak, yellow poplar, and maple; while telephone booths—in which appearance is important—are made from such woods as oak and birch. Yellow poplar and oak are used for the base blocks for electrical devices; while many high-grade woods are used in switchboards and telephone cabinets.

Illinois seems to be the most prominent state in the manufacture of electrical machinery and apparatus, but large quantities are also produced in New York and Pennsylvania.

FIG. 75.—Maple Last Blocks.

FIG. 77.—Bales of Cedar Shavings from a Shingle Mill.

FIG. 76.—Veneered Door of Curly Birch Inlaid with White Holly and Black Walnut.

FIG. 78.—Norway Pine and Paper Birch.

TABLE 50

ELECTRICAL MACHINERY AND APPARATUS

(Annual lumber consumption, 15 million board feet)

Woods Used	Per Cent
Oak	27
White Pine	17
Spruce	11
Yellow Pine	7
Maple	7
Birch	4
Cedar	4
Larch	4
Yellow Poplar	3
Elm	3
Walnut	3
Beech	2
Mahogany	2
Basswood	2
Hemlock	1
Red Gum	1
Cypress	1
Other Woods	1
Total	100

37. Brushes.—The manufacture of brushes consumes about 11 million feet of wood annually of more than thirty species, of which beech supplies nearly half, and birch and maple each 15 per cent.

There are so many different kinds, grades, and sizes of brushes and brooms that there is a wide range in the quality of material employed. The more expensive hand brushes have backs artistically turned from ebony, mahogany, rosewood, maple, cherry, walnut, and birch; while, for scrubbing and whitewash brushes, beech is very largely used. Maple, beech, and birch are employed for paint brushes, as well as for duster handles. For many of the cheaper brushes, various woods are used.

Pennsylvania uses more wood than any other state in the manufacture of brushes; while Ohio, New York, Maryland, Maine, and Massachusetts are also prominent in the production of these articles.

TABLE 51

BRUSHES

(Annual wood consumption, 11 million board feet)

Woods Used	Per Cent
Beech	49
Birch	15
Maple	15
Basswood	6
Cherry	4
Red Gum	2
Yellow Poplar	2
Elm	1
Hickory	1
Other Woods	5
Total	100

38. Dowels.—Dowels are wooden pegs used to hold boards together, edge to edge, in the manufacture of table tops and counters, or to hold the parts of sash, doors, and similar articles together. They are usually made of the strongest hardwoods, and are driven tightly into auger or gimlet holes to make strong, close-fitting joints. More than 90 per cent of the dowels are made from birch, beech, and maple, and especially from paper birch. Dowels are occasionally made from oak, hickory, or ash.

Dowel rods are also used in the manufacture of chairs, children's beds, and cribs, and for coops in which poultry is shipped.

TABLE 52

DOWELS

(Annual wood consumption, 10 million board feet)

Woods Used	Per Cent
Birch	68
Beech	15
Maple	11
Elm	1
Basswood	1
Other Woods	4
Total	100

The equivalent of about 10 million board feet of lumber is annually consumed in dowel making, and nearly two-thirds of it in Maine. Michigan and New York also produce dowels in considerable quantities.

39. Elevators.—Under this heading is included the wood used in the manufacture of elevators and elevator parts, including gates, dumb waiters, platforms, guides, and frames.

Ash and oak are frequently used for the framework and heavy platforms of freight and passenger elevators. Maple is principally used for elevator floors and guides; while white and yellow pine are also used for guides, frames, and platforms in places where great strength is not required. Dumb-waiter cars are made from maple, ash, birch, and some of the lighter woods. Elevator finish is often made of yellow poplar. In the more highly finished elevators, mahogany, ash, birch, walnut, and oak are used for interior trim.

New York is the leading state in the manufacture of elevators, while Iowa, Illinois, Indiana, and Pennsylvania follow closely in this industry.

TABLE 53

ELEVATORS

(Annual lumber consumption, 8 million board feet)

Woods Used	Per Cent
Yellow Pine	36
White Pine	17
Maple	16
Hemlock	10
Oak	10
Douglas Fir	4
Yellow Poplar	3
Ash	1
Other Woods	3
Total	100

40. Saddles and Harness.—Strength is an essential element in the woods used in saddle and harness making; so 98 per cent of them are hardwoods, among which beech and ash are the most prominent.

The principal parts in which wood is used are saddle trees, stirrups, and hames. Ash is largely used for hames, and to some extent, also, are beech, maple, and oak. Stirrups are made of elm or hackberry, with the best ones of oak. In the west, Douglas fir, as well as Oregon maple, is used for saddle trees. Pack saddles are made from Oregon cottonwood, alder, or ash.

TABLE 54

Saddles and Harness

(Annual wood consumption, 9 million board feet)

Woods Used	Per Cent
Beech	30
Ash	23
Maple	16
Oak	14
Red Gum	12
Elm	3
Douglas Fir	1
Other Woods	1
Total	100

41. Playground Equipment.—Under this heading are included merry-go-rounds, lawn and other swings, athletic platforms, and various field appliances. Since nearly all such equipment requires strength and wearing qualities, it is not surprising that almost 90 per cent of the 8 million feet of wood annually used for this purpose consists of beech, oak, yellow pine, and maple.

Because of its strength and toughness, beech is much used for swings where subject to vibration and irregular strains. Longleaf pine is much used for the platform sills of merry-go-rounds; and so are also Douglas fir and oak. Birch and other woods are used for lawn swings and settees; and black ash, for porch swings. Elm is frequently used for bent parts in playground equipment; and maple, for the exterior finish of merry-go-rounds.

Among the more prominent states in the manufacture of such equipment are Indiana, Pennsylvania, Michigan, and Ohio.

TABLE 55

PLAYGROUND EQUIPMENT

(Annual lumber consumption, 8 million board feet)

Woods Used	Per Cent
Beech	34
Oak	28
Yellow Pine	16
Maple	9
Elm	4
Ash	2
Birch	2
Spruce	1
Hickory	1
Yellow Poplar	1
Other Woods	2
Total	100

42. Insulator Pins and Brackets.—Practically the only woods used in the manufacture of insulator pins and brackets are black locust and white or chestnut oak. Because of its exceedingly great strength and durability, black locust has always been the favorite wood for this purpose, but the demand for pins and brackets has become so great that much oak also is now used, the pins and brackets of this wood being given a treatment with a preservative to prevent decay. On high-power lines with large porcelain insulators, hickory pins are used to some extent.

Nearly all of the insulator pins and brackets are manufactured in North Carolina and Virginia, where suitable raw material is most abundant.

TABLE 56

INSULATOR PINS AND BRACKETS

(Annual wood consumption, 8 million board feet)

Woods Used	Per Cent
Locust	53
Oak	47
Total	100

43. Butcher Blocks and Skewers.—Butcher blocks are chiefly made from maple, red gum, and sycamore; while skewers are made most largely from hickory, beech, and birch. Strength and toughness are essential qualities in skewers, since they must be of small size; while a dense fiber that resists chopping and does not splinter up is required for meat blocks. In the earlier days, these blocks were chiefly made from solid sections of sycamore, but the practice at present is to build them up from ordinary sizes of lumber though they are still made in considerable number from solid sycamore sections.

TABLE 57

BUTCHER BLOCKS AND SKEWERS

(Annual wood consumption, 7 million board feet)

Woods Used	Per Cent
Maple	26
Red Gum	22
Sycamore	20
Hickory	16
Beech	11
Birch	3
White Pine	2
Total	100

44. Clocks.—The clock-making industry in the United States requires annually the equivalent of about 7 million feet of lumber, used chiefly for cases. Large clocks of the grandfather type are now much in fashion; and in the making of such cases, some of the finer woods and the highest class of work are employed. Oak is much used for clock frames; birch, for turnery; and walnut, mahogany, and cherry, for decorative effects in the higher-priced articles. Clock bottoms are made of pine; while the shipping cases are frequently made from yellow pine, which accounts for much of this wood shown in Table 58. Red oak is much used in the manufacture of cases for wall clocks; and basswood and yellow poplar for backs and also for cases which are to be enamled. Red gum is used to a considerable extent for cases in which a Circassian walnut effect is desired.

About 60 per cent of the wood used in clock manufacture is consumed in Connecticut, and nearly all the rest in New York, these two states being the only ones in which clock-making is an extensive industry.

TABLE 58

CLOCKS

(Annual lumber consumption, 7 million board feet)

Woods Used	Per Cent
Oak	33
Basswood	18
Yellow Poplar	14
Yellow Pine	12
White Pine	6
Tupelo	4
Cherry	4
Chestnut	4
Mahogany	3
Other Woods	2
Total	100

45. Signs and Supplies.—Under this heading are included the manufacture of professional display boards, stretcher strips for oil paintings, window display racks, and similar articles.

TABLE 59

SIGNS AND SUPPLIES

(Annual lumber consumption, 6 million board feet)

Wood Used	Per Cent
White Pine	47
Hemlock	15
Western Yellow Pine	15
Yellow Pine	6
Red Gum	3
Elm	3
Redwood	2
Maple	1
Yellow Poplar	1
Basswood	1
Cottonwood	1
Buckeye	1
Other Woods	4
Total	100

White pine, hemlock, and Western yellow pine are much used for these purposes because of their light weight and color, ease of working, and capacity to take paints and oils, the latter being specially required for many kinds of signs. The hardwoods grouped in this classification are chiefly used for display racks and hangers.

Many of the large bill posting boards are not special factory products, but are simply made by nailing up tongued-and-grooved flooring on supports—many of the larger billboards are sheet metal on a frame of timbers.

46. Printing Materials.—The equivalent of more than 4 million board feet of lumber is annually used in the manufacture of printing materials, of which cherry supplies nearly two-fifths. This classification includes engraving blocks, electrotype blocks, engraving boards, and printing press attachments. Engraving and electrotype blocks and bases are generally made of cherry, basswood, oak, birch, maple, or beech, and sometimes of mahogany. Engravers' boards are generally made of basswood; and the long wooden fingers on cylinder presses, from ash. For large wood type which must stand up under heavy service, the hardest of hard maple is used.

TABLE 60

Printing Materials

(Annual lumber consumption, 4 million board feet)

Woods Used	Per Cent
Cherry	39
Maple	13
Ash	7
Basswood	7
Yellow Pine	6
Beech	5
Oak	5
Chestnut	5
Birch	5
Yellow Poplar	3
Elm	2
Mahogany	1
Other Woods	2
Total	100

Among the more prominent states in the consumption of wood for printing materials, are New York, Pennsylvania, Michigan, and Maine.

47. Weighing Apparatus.—Approximately the same amount of wood is used in the manufacture of weighing apparatus or scales of various kinds as is required for printing devices and machines. The qualities required are different, however; and consequently we find that three-fifths of the wood used in the manufacture of weighing apparatus consists of spruce and yellow pine, which offer desirable combinations of light weight and strength. Three other harder and stronger woods used to less extent are maple, birch, and beech; while white pine, oak, Douglas fir, yellow poplar, and a half-dozen others make up the remaining 10 per cent of wood material consumed in this industry.

TABLE 61

WEIGHING APPARATUS

(Annual lumber consumption, 4 million board feet)

Woods Used	Per Cent
Spruce	36
Yellow Pine	24
Birch	14
Maple	9
Beech	7
White Pine	3
Oak	3
Douglas Fir	2
Yellow Poplar	1
Other Woods	1
Total	100

48. Whips, Canes, and Umbrella Sticks.—The manufacture of such apparently small articles as whips, canes, and umbrella sticks annually requires the equivalent of 4 million board feet of lumber, although much of the material is never put into lumber form, and the rarer imported kinds are purchased by the piece or pound.

Among the native woods used for this purpose, beech supplies 57 per cent of the total consumption; and maple and

birch 33 per cent more, leaving only 10 per cent for some twenty other species. Beech is largely used for whip stocks and umbrella sticks, as are also maple and birch. Handles are frequently made from ebony, while many imported woods and roots are used for the more expensive cane and umbrella sticks.

TABLE 62

WHIPS, CANES AND UMBRELLA STICKS

(Annual wood consumption, 4 million board feet)

Woods Used	Per Cent
Beech	57
Maple	22
Birch	11
Ebony	4
Hickory	2
Other Woods	4
Total	100

In the manufacture of these articles, New York and Massachusetts hold equal rank, each supplying about 40 per cent of the total product, while the bulk of the remainder comes from Pennsylvania.

49. Brooms and Carpet-Sweepers.—Ordinary broom handles are listed with handles; hence this classification relates chiefly to carpet-sweepers.

TABLE 63

BROOMS AND CARPET-SWEEPERS

(Annual lumber consumption, 1 million board feet)

Woods Used	Per Cent
Maple	25
Birch	23
Oak	18
Sycamore	12
Ash	10
Red Gum	5
Beech	4
Mahogany	2
Circassian Walnut	1
Total	100

The manufacture of carpet-sweepers on a large scale is a strictly modern industry, and is centered in Michigan. The making of carpet-sweepers has come to be quite an art; and these articles are finished in a wide variety of durable and ornamental woods, in order to match many styles of house finish and furniture. In addition to the nine woods listed in Table 63, rosewood, laurel, and black walnut are recorded as being used to some extent in the manufacture of carpet-sweepers.

50. Firearms.—Black walnut has been the favorite gunstock wood for many years, and still supplies four-fifths of the wood used in the manufacture of firearms. More recently, however, red gum has come into prominence for stocks in which a Circassian walnut effect is desired, while a small percentage of the more expensive firearms carry stocks of the true imported walnut. A small amount of English walnut is also used for pistol stocks, and birch occasionally for gun stocks, while boxwood is a favorite material for gun rods

Gunstocks are made chiefly in Connecticut, Michigan, New York and Massachusetts. Table 64 does not include war orders.

TABLE 64

FIREARMS

(Annual lumber consumption, 1 million board feet)

Woods Used	Per Cent
Black Walnut	81
Red Gum	17
Circassian Walnut	2
Total	100

51. Minor Uses.—There are three smaller but important wood-using industries which in the aggregate do not consume much more than the equivalent of 1 million board feet of wood yearly. These are the manufacture of artificial limbs, tobacco pipes, and airplanes.*

* Data based on pre-war conditions.

TABLE 65

Minor Uses of Wood in Manufacturing

(Total annual wood consumption, 1 million board feet)

Artificial Limbs—	Per Cent
Birch	51
Maple	21
Willow	8
Hickory	6
Yucca	6
Lancewood	4
Other Woods	4
Total	100
Tobacco Pipes—	Per Cent
French Brier	66
Apple	25
Kalmia	4
Red Gum	2
Other Woods	3
Total	100
Airplanes—	Per Cent
Spruce	63
Ash	16
Mahogany	8
Yellow Poplar	6
Oak	5
Hickory	2
Total	100

The requirements for airplane wood are most exacting. Above all, it must be straight-grained, strong, light, and perfectly free from defects. The upright posts which hold the planes apart are chiefly made from spruce. Airplane beams are generally of spruce. Ash is often used for the laminated propellers, while hickory is used for the axles and the braces over them. Propellers are also made either wholly of spruce or of built-up layers of ash and mahogany. Mahogany is used in the steering wheels. The skids which hold the landing wheels are usually of oak, ash, or hickory.

CHAPTER XVI

COMMERCIAL WOODS

The properties and uses of the principal kinds of timber that are manufactured into lumber in the United States are briefly mentioned in this chapter; also those of the more important imported woods. The various species are referred to by the names by which they are most widely known; and the order is alphabetic, without regard to the importance of any species in point of lumber production.

Table 107, on page 340, shows the pre-war average annual lumber production in the United States. A large percentage of the lumber output, estimated at from 60 to 70 per cent, goes directly into general building and construction, and there is no way in which the specific uses of such material can be ascertained. The figures given in this chapter upon the consumption of lumber represent chiefly the results of the state and government studies of the wood-using industries, during the course of which a great deal of valuable information has been accumulated upon the factory uses of wood. In order to avoid tiresome figures and to show the true proportions more readily, the tables made up from the statistical reports are in percentages; that is, the percentage of the total factory consumption of each species is shown for each industry in which the species is used, the total factory consumption in each case being 100 per cent.

RED ALDER

Red alder (*Alnus oregona*) is a Pacific coast hardwood, found chiefly west of the Cascade mountains in Oregon and Washington. The wood is reddish brown in color, with rather fine, even grain, compact, and hard. It works and polishes well, and makes a good imitation of mahogany when desired.

Fig. 79.—White Ash Timber. (Contains Some Red Oak and Cherry.)

The main factory uses of red alder are shown in Table 66.

TABLE 66

FACTORY USES OF RED ALDER

Purpose	Per Cent
Furniture	63
Millwork	19
Handles	16
Other Uses	2
Total	100

The specific uses reported for red alder are for archery bows, broom handles, columns, tables, interior finish, pack saddles, pulleys, and turnery.

APPLE

The domestic apple tree supplies a very compact hardwood that is much prized for a number of small articles. While apple wood is generally cut only when old orchards are cleaned out, the reports indicate a factory consumption of about 300,000 board feet of this wood yearly. The main items of use are as indicated in Table 67.

TABLE 67

FACTORY USES OF APPLE WOOD

Purpose	Per Cent
Handles	48
Tobacco Pipes	38
Professional and Scientific Instruments	8
Boxes and Crates	4
Other Uses	2
Total	100

More specifically, applewood is used in the manufacture of planes, mallets, saw handles, rules, canes, and tobacco pipes.

Fig. 80.—A Douglas Fir Forest.

ASH

Botanists distinguish a number of species of ash in the United States; but, for commercial purposes, only three are usually specified—white ash, black or brown ash, and Oregon ash.

White ash (*Fraxinus americana*) is slightly under the average weight and hardness of hardwoods, but of more than average strength and stiffness, which makes it very useful for many purposes.

Green ash (*Fraxinus lanceolata*) is the principal source of ash lumber in the Southern states, but is not commonly distinguished from white ash.

Black ash (*Fraxinus nigra*) is somewhat softer and weaker than white ash. It is much less generally distributed throughout the Eastern states than the former, and is most largely manufactured in Wisconsin and Michigan. The toughness of black ash made it popular wood for split hoops for many years.

Oregon ash (*Fraxinus oregona*), while not very abundant in that state, yields a hard, strong, tough wood which takes an excellent polish and hence is useful for fixtures and furniture in addition to its main use for handles.

The statistical reports do not separate the various species of ash, and their uses are summarized in Table 68.

TABLE 68

FACTORY USES OF ASH

Purpose	Per Cent
Handles	22
Woodenware	21
Vehicles	15
Furniture and Fixtures	8
Millwork	7
Refrigerators and Kitchen Cabinets	6
Car Construction	6
Agricultural Implements	4
Boxes and Crates	4
Ship and Boat Building	3
Sporting and Athletic Goods	1
Other Uses	3
Total	100

In addition to the above, particular uses for white ash are for:

Airplanes
Automobiles (running boards)
Bars (vehicle)
Baseball bats
Bent panels (light vehicle bodies)
Beams (cultivators)
Baby perambulators
Bobsleds
Bows
Boxes
Butter tubs (heading)
Butter tubs (staves)
Cabinet work
Car construction (framing)
Car repairing
Chairs
Church pews
Churns
Churn lids
Corn planters
Cylinders (cider mill)
Doors
Dowels
Electrical apparatus
Elevator parts
Engine cabs
Felloes
Flooring
Frames (automobile bodies)
Frames (buggy and carriage bodies)
Frames (light vehicle seats)
Frames (wagon boxes)
Furniture
Gears (coach)
Handles
Handles (edge tool)
Hames (wood)
Harrows
Hoe handles
Hose truck bodies
Hounds (vehicles)
Interior finish
Machinery (construction)
Kitchen cabinets
Keels (boat)
Moldings
Panels
Parallel bars
Patterns
Piano parts
Planing mill products
Plow beams
Pokes (animal)
Poles (heavy vehicles)
Posts (vehicles)
Plumbers' woodwork
Pump rods
Rails
Rake heads
Rake (garden) handles
Rims (vehicle)
Refrigerators
Sash
Shovel handles
Soil rollers
Staves
Tables
Tools
Trunks
Vehicle bodies and parts
Yokes
Wagon parts
Well-digging machines
Windmills

Black ash enters into the manufacture of:

Auto seats
Baseball bats
Boat finish
Box shooks
Buffets (exterior work)
Buffets (inside work)
Butter tubs
Candy pails

Chairs (kitchen)
Commodes
Cooperage stock
Desks (inside work)
Fixtures
Flooring
Furniture (interior)
Handles (garden tools)
Handles (small tools)
Hayloader parts
Hoops (butter tubs)
Hoppers (fruit and vegetable)
Ice chests
Interior finish
Kitchen cabinets
Lard tubs
Moldings (piano)
Music cabinets (inside work)
Music cabinets (exterior work)
Picture moldings
Pike poles
Racked hoops
Refrigerators
Sills (vehicle)
Spice kegs
Slats (bed)
Sugar buckets
Trunk slats
Washboards

Oregon ash is used on the Pacific coast in making boats, book cases, chairs, desks, tables, handles, saddles, and vehicles.

ASPEN

The aspens, of which there are two species—the common popple or quaking aspen (*Populus tremuloides*), and the large-tooth aspen (*Populus grandidentata*)—are widely distributed throughout the United States, and belong to the family of true poplars, of which the cottonwoods are the largest representatives. The wood of the aspens is light in weight and color, soft, and not strong. In stiffness, however, it ranks with many heavier hardwoods.

Aspen is not separately tabulated in many state reports; but probably its largest use is for the making of boxes and crates, to which purpose it is excellently suited. Some of the specific uses listed for aspen are as follows:

Basket bottoms
Basket hoops
Boxes
Boxes (piano)
Boxes (shoe pegs)
Boxes (veneer)
Brushes
Buckets
Casing
Ceiling
Crates
Dowels
Excelsior
Fish kits
Frames (door)
Frames (window)

Furniture (hidden work)
Handles (dipper)
Handles (oyster knife)
Jelly buckets
Novelties
Pails
Shoe fillers
Shoe forms
Shoe lasts
Shoe trees
Spice kegs
Spool heads
Spools
Sugar buckets
Toothpicks
Toys
Toy wheelbarrows (bodies)
Vehicle body parts
Wood wool

BALM OF GILEAD

Balm of Gilead (*Populus balsamifera*) is also a true poplar; and the wood is much like that of its relatives with respect to weight, strength, and uses. The supply is not large, since the tree occurs but infrequently in the Northern states.

Balm of Gilead is used chiefly in the manufacture of boxes and crates, but also has a place in the making of the following articles:

Berry buckets
Built-up panels
Card-table tops
Ceiling
Druggist barrels
Egg-cases
Excelsior
Furniture shelving
Grape baskets
Handles
Hat racks
Novelties
Pails
Spindles
Tubs
Wood wool

BASSWOOD

With the possible exception of willow and buckeye, basswood (*Tilia americana*) is the lightest, softest, and weakest of the hardwoods. It is neither stiff nor tough, but, because of its even grain, white color, and extreme ease of working, is one of the most widely used woods. The more important factory uses reported are as shown in Table 69.

TABLE 69

FACTORY USES OF BASSWOOD

Purpose	Per Cent
Boxes and Crates	23
Millwork	16
Woodenware and Novelties	15
Furniture and Fixtures	11
Trunks and Valises	6
Picture Frames and Molding	5
Excelsior	4
Musical Instruments	3
Toys	2
Agricultural Implements	2
Vehicles	2
Matches	1
Refrigerators and Kitchen Cabinets	1
Car Construction	1
Laundry Appliances	1
Tobacco Boxes	1
Other Uses	6
Total	100

The diversity of the uses of basswood is indicated by the following list of articles in the manufacture of which this wood is used to a greater or less degree:

Agricultural implements
Altars
Apparatus parts (electric)
Automobiles
Backings (furniture)
Backs (organ)
Baseboards
Baskets (fruit and vegetable)
Beehives
Bellows (organ)
Boats
Bookcases (inside work)
Boxes
Breadboards
Bureaus (inside work)
Butter ladles
Cabinets (kitchen)
Cameras
Candy pails
Car construction
Car repairing
Casings (building)
China closets (interior work)
Church pews
Circus seats
Cigar boxes
Cleats (organ)
Clothes bars
Commodes
Coops (poultry)
Cornice
Corn shellers
Couches (box)
Crating
Cupboards
Desks (school)

Drawer bottoms
Engraving boards
Fans (electric)
Feed mills
File cases
Fixtures (bar)
Fixtures (barber shop)
Fixtures (store and office)
Flag poles
Frames (couches)
Frames (davenports)
Frames (hand mirror)
Frames (lounges)
Furniture (church)
Furniture (interior)
Gameboards
Games of chance
Go-carts
Grain separators
Guitars
Handles
Hayloader parts
Heading (barrels)
Hoppers (fruit and vegetable)
Incubators (bodies)
Ironing boards
Interior finish (buildings)
Kitchen cabinets
Ladders (extension)
Laundry machinery
Lodge furniture
Machinery construction
Mandolins
Millwork
Moldings (casket)
Music cabinets (interior)
Organ cases (folding organ)
Organ frames
Pails
Parlor furniture (frames)
Pastry boards
Patterns
Piano keys
Picture molding
Pipe organs (interior parts)
Pyrography boards
Refrigerators
Sample cases
Seeder boxes (farm implements)
Sheathing (building)
Shoe forms
Siding (house)
Signboards
Staves
Stirrups (head blocks)
Stirrups (neck blocks)
Swing seats
Tables
Thermometers
Threshing machines
Toys
Trunks
Vehicle bodies
Violin cases
Washboards
Washing machines
Yardsticks

BEECH

Beech (*Fagus atropunicea*) is a moderately hard, strong, heavy hardwood that has a wide range of usefulness for many purposes. While the reports indicate a larger consumption of beech in the manufacture of boxes and crates than in any other industry, a large amount is used in general millwork, including flooring and finish, and for furniture and fixtures, for which purposes the hardness and wear resisting qualities of beech are especially desirable.

TABLE 70

FACTORY USES OF BEECH

Purpose	Per Cent
Boxes and Crates	28
Millwork	21
Furniture and Fixtures	18
Handles	6
Woodenware and Novelties	5
Laundry Appliances	3
Brushes	2
Vehicles	2
Agricultural Implements	2
Musical Instruments	1
Spools and Bobbins	1
Toys	1
Playground Equipment	1
Whips, Canes, etc.	1
Saddles and Hames	1
Other Uses	7
Total	100

A still better idea of the varied uses of beech is obtained from the following partial list of articles into the manufacture of which this wood enters:

Agricultural implements
Auto-seat frames
Balls
Barber chairs
Baseball bats
Baskets
Beds (folding)
Boats
Bobbins
Boxes
Brick molds
Broom handles
Brushes
Built-up panels
Bungs
Butcher blocks
Butter dishes
Butter tubs
Cable reels
Candy pails
Cars
Chair bottoms
Chair rods
Cheese boxes
Churns
Cider mills
Clocks
Clothes pins
Coat hangers
Coops
Crating
Dowels
Drafting tables
Electrotype plates
Faucets
Filing cabinets
Fixtures
Furniture

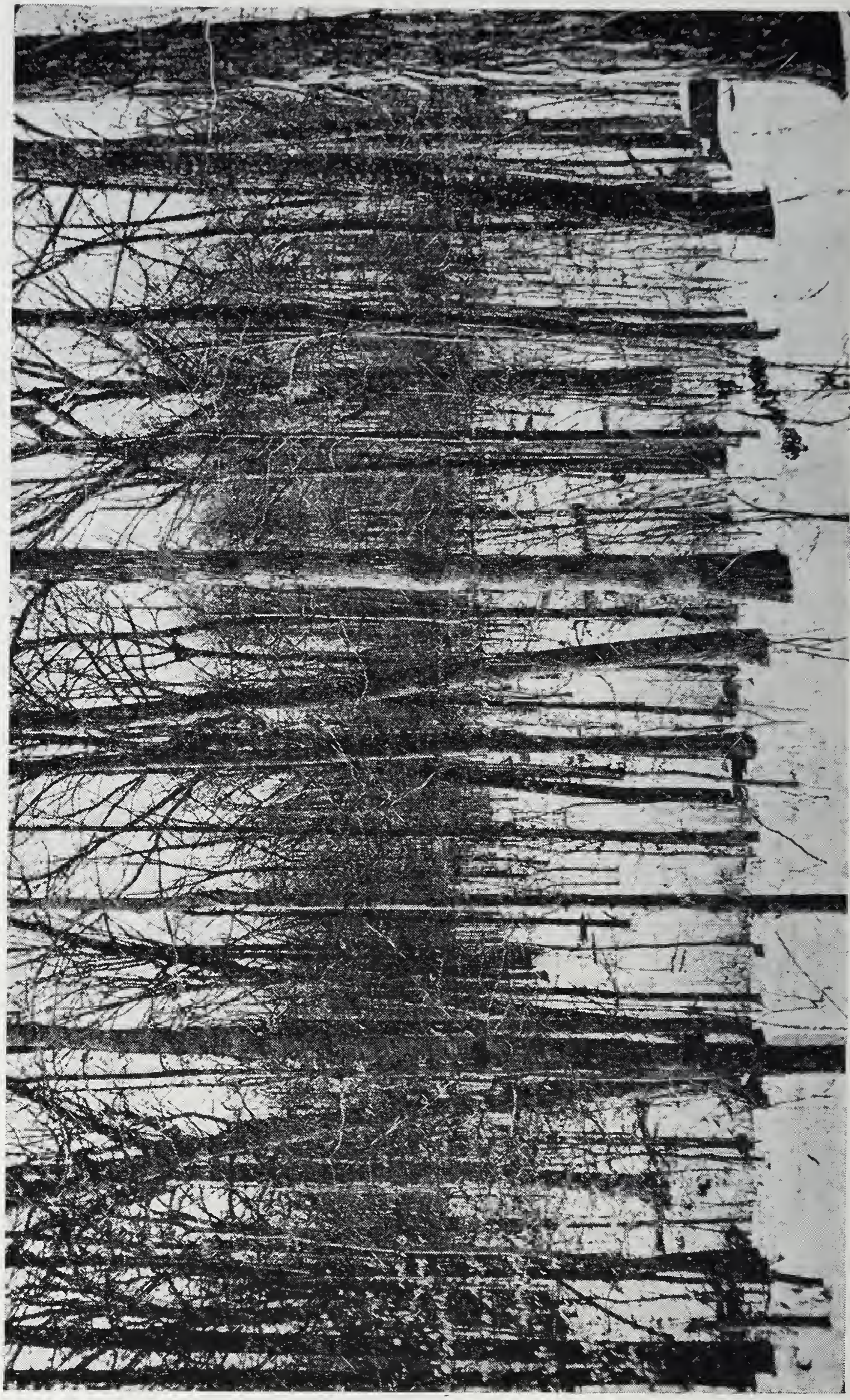

FIG. 81.—Mixed Forest of White Oak and Hickory.

- Hames
- Handles
- Hand sleds
- Interior finish
- Ironing boards
- Ladders
- Lawn swings
- Measures
- Musical instruments
- Mouse traps
- Neck yokes
- Novelties
- Pails
- Panels
- Piano cases
- Pipe organs
- Plane stocks
- Printers' cabinets
- Pulleys
- Pumphandles
- Pump buckets
- Refrigerators
- Rims (bicycle)
- Rope reels
- Sash
- Sectional bookcases
- Show cases
- Skates
- Sounding boards
- Spindles
- Spools
- Stanchions
- Staves
- Stepladders
- Tables
- Tie plugs
- Toys
- Trunks
- Tubs
- Vehicles
- Wardrobes
- Washing machines
- Washboards
- Weighing machines
- Wheelbarrows
- Window screens
- Woodenware

BIRCH

Several birches are recognized by botanists and foresters; but from the standpoint of the practical wood user, there are only three important kinds—the paper or white birch (*Betula papyrifera*), the yellow birch (*Betula lutea*), and the red or cherry birch (*Betula lenta*). Paper birch is found across the northern part of the United States and Canada, but is most abundant and commercially important in New England, and especially in Maine. The red or cherry birch occurs in smaller quantity from New York southward through West Virginia; while the yellow birch is common in New York, New England, and the Lake States, but most abundant in the latter region. The heartwood of yellow birch is reddish, and much of it is marketed and used for the same purposes as cherry birch, and, without distinction from the latter, for the manufacture of furniture, interior finish, and the like. The principal uses of the paper or white birch are for spool stock, box lumber, handles, dowels, shoe pegs, and other small articles. Closely related to the paper birch is the

FIG. 82.—Second-Growth White Pine—Trees 50 to 60 Years Old.

Western birch (*Betula occidentalis*), a small amount of which is used for interior finish in Oregon and Washington.

The wood of red and yellow birch is heavy; of average hardness, stiffness, and strength for hardwood; and above the average in toughness. For this reason, birch makes a good wagon hub; and much yellow birch is used for this purpose.

The factory uses of the various birches are summarized in Table 71.

TABLE 71

FACTORY USES OF BIRCH

Purpose	Per Cent
Millwork	28
Furniture and Fixtures	21
Boxes and Crates	19
Spools and Bobbins	7
Woodenware and Novelties	6
Vehicles	3
Musical Instruments	3
Handles	2
Dowels	2
Boot and Shoe Findings	2
Car Construction	1
Agricultural Implements	1
Other Uses	5
Total	100

A tabulation of the uses reported for red and yellow birch gives the following list:

Automobiles
Backgrounds (display windows)
Balusters
Barber chairs
Barber shop furnishings
Barrel starchers (laundry)
Baseboards
Baskets (fruit and vegetable)
Billiard tables
Boat parts
Bobbins
Bodies (light vehicles)
Bookcases (exterior)
Bookcases (interior)
Bookracks
Bottoms (heavy vehicle bodies)
Bottoms (wagons)
Boxes
Boxes (cheese)
Boxes (veneer)
Box shooks
Brackets
Broom handles
Brush blocks
Buffets (bar fixtures)
Bureaus (exterior)
Butter churns (frames)
Butter molds
Cabinets (music rolls)
Cabinets (phonograph records)

Cabinets (toilets)
Cabinet work
Cameras
Canes
Capitals
Carpet sweepers
Carvings
Cases (medicine)
Cases (railroad tickets)
Casing
Caskets
Chair frames (upholstered furniture)
Chairs
Chairs (adjustable)
Chairs (dining room)
Chair seats
Chairs (office)
China closets
Clocks
Coffins
Columns (porch)
Consoles
Cooperage stock (slack)
Cores (veneer)
Counters (bar)
Counters (store and office fixtures)
Cradles
Crating
Creamery accessories
Crutches
Cutting boards (meat)
Doors
Dowels
Dressers
Dressing tables
Electrotype bases
Elevator cars
Equipment (playground)
Farm implement parts
Farm machinery parts
Fixtures (bank)
Fixtures (laboratory)
Fixtures (soda fountain)
Fixtures (store and office)
Flooring
Folding beds
Frames (cheval mirror)
Frames (couches)
Frames (davenports)
Frames (light vehicle bodies)
Frames (light vehicle seats)
Frames (lounges)
Gameboards
Gear parts (light vehicles)
Glove boxes
Grain doors
Grilles
Grille work
Guitars
Hallracks
Handrails (porch
Handrails (stairworks)
Harp sides (musical instrument)
Hoppers (fruit and vegetable)
Hubs
Interior finish
Key racks
Launch parts
Laundry machines (steam)
Lawn swings
Leaves (table)
Lining (motor boats)
Mandolins
Mantels
Match safes
Match strikers
Mirror backs
Moldings (house)
Moldings (piano)
Newels (stairwork)
Organ cases
Organ cases (exterior pipe organ)
Organ keys
Ornaments (furniture)
Panels (veneered)
Paper plugs
Parlor cabinets (exterior)
Parlor furniture (frames)
Parlor rockers
Parquetry flooring
Passenger cars (interior finish)
Patterns (machine parts)
Pedestals
Pen racks

Pen trays
Piano benches
Piano cases
Piano chairs
Piano keys
Piano players (exterior)
Piano stools
Picture mouldings
Plane handles
Plumbers' woodwork
Pool tables
Pulleys
Posts (stairwork)
Reels (fence wire)
Reels (insulated wire)
Refrigerators
Risers (stairwork)
Road machinery parts
Rocker frames (upholstered furniture)
Sash (window)
Screen doors
Seats (water closets)
Sewing machine parts
Sewing tables
Shells (drum)
Shoe pegs
Shoe trees
Show cases
Sideboards (exterior)
Sills (road carts)
Skewers
Skis
Sleds
Slids (tables)
Sofa frames (parlor furniture)
Somnols
Spools
Stairwork
Steering wheels
Step ladders
Steps (stairwork)
Switchboards (telephone)
Tables
Tables (dressing)
Tables (library)
Tabourets
Tanks (water closets)
Telephones
Telephones (accessories)
Toboggans
Tool chests
Toys
Trunks
Umbrella handles
Veneer cores (piano cases)
Wainscoting
Wall cases (store)
Wardrobes (exterior)
Window screens
Wind shields (automobile)
Woodenware
Work benches
Zither bodies

Among the uses reported for paper or white birch are:

Bails (bucket and pail)
Bobbins
Boxes
Brushes
Camp stools (parts)
Chairs (porch)
Chairs (turned parts)
Checkers
Clothespins
Crates
Crutches
Dowels
Drawer sides
Dry measures
Duster brush blocks
Flooring
Furniture
Handles (awl)
Handles (cant hook)
Handles (corkscrew)
Handles (feather curlers)
Handles (hair curlers)
Handles (hay rake)
Handles (long handle brushes)

Handles (long handle)
Handles (paint brushes)
Handles (shovel)
Handles (toy garden tools)
Hosiery (boards)
Hoops
Interior finish
Knobs
Molding (window)
Novelties
Paint brushes
Paper plugs
Piano stools
Quills
Rungs (turned chair)
Sawhorses
Shoe pegs
Skewers
Speeders
Spindles (turned chair)
Spinning wheels
Spools
Spool barrels
Spool heads
Table slides
Toothpicks
Toy parts (iron toys)
Toy wheelbarrows
Twisters
Vehicle parts
Wash benches
Wash boards
Wheels (toy wagons)
Wheels (toy wheelbarrows)

BUCKEYE

Buckeye (*Aesculus octandra*) is a species of the horse-chestnut family from which about 5 million feet of lumber are annually manufactured in Ohio, Kentucky, and adjacent States. The wood is very much like basswood as regards lightness in weight, softness, and lack of toughness or strength. That these qualities make buckeye useful for very many of the purposes for which basswood is desired, will be seen from the summary of its factory uses given in Table 72.

TABLE 72

FACTORY USES OF BUCKEYE

Purpose	Per Cent
Boxes and Crates	47
Excelsior	19
Millwork	10
Furniture	6
Trunks and Valises	6
Frames and Molding	3
Caskets and Coffins	3
Laundry Appliances	2
Woodenware and Novelties	1
Signs and Supplies	1
Other Uses	2
Total	100

Some of the specific uses reported for buckeye include doors, piano panels, interior finish, sample cases, candy and chocolate boxes, and wooden bowls and dishes.

BUTTERNUT

Butternut (*Juglans cinerea*) is in much the same class as basswood and buckeye in respect to mechanical qualities, but is slightly heavier, harder, stronger, and tougher than these woods. It also has a figure considerably like black walnut, of which it is a close relative, but lacks the rich color of the more valuable wood.

Butternut finds its largest usefulness in the manufacture of furniture and fixtures, and, next, for boxes and crates, as is indicated in Table 73.

TABLE 73

FACTORY USES OF BUTTERNUT

Purpose	Per Cent
Furniture and Fixtures	39
Boxes and Crates	22
Excelsior	11
Millwork	9
Woodenware and Novelties	6
Musical Instruments	4
Ship and Boat Building	3
Patterns and Flasks	2
Professional and Scientific Instruments	1
Other Uses	3
Total	100

Specific articles in which butternut is used are:

Altars
Boat decks
Boat finish
Boat seats
Cabinets
Cameras
Caskets
Cheese box heading
Church pews
Doll carriages
Furniture
Interior finish
Molding
Patterns
Piano cases
Piano molding
Screen frames
Show cases
Store fixtures
Tables
Threshing machines
Toys
Vehicles

CEDAR

There are so many woods popularly known by the name "cedar," that this name conveys little idea of the qualities of the timber referred to. Some of these woods are correctly known as cedar, while entirely different names are applied by botanists to the others. In this discussion, it is sufficient to mention seven species which go by the name of cedar, and which have a considerable commercial usefulness—the Southern white cedar (*Chamaecyparis thyoides*) of the Atlantic Coast states; the Northern white cedar or arbor vitae (*Thuja americana*), chiefly important in New England and the Lake States; the red or pencil cedar (*Juniperus virginiana*), which is most abundant in Tennessee and Florida; the Western red cedar or giant arbor vitae (*Thuja plicata*) of the Northern Rocky Mountains and Pacific Northwest; the Port Orford cedar (*Chamaecyparis lawsoniana*) of Oregon; the Alaska or yellow cedar (*Chamaecyparis nootkatensis*) of the North Pacific Coast from Oregon to Alaska; and the incense cedar (*Librocedrus decurrens*) of Southern Oregon and California. All of these so-called cedars have in common a certain lightness in weight, softness, evenness of grain, and resistance to decay, but in varying degrees.

Both the Northern and Southern white cedars are among the lightest of woods in weight, and are soft and easily worked. They are much used for woodenware and in canoe and boat building, and also for shingles, posts, and poles, by far the larger part of the Northern white cedar being used for the latter purpose. The true red or pencil cedar has always been the standard wood for lead pencils, because it is very soft, with a fine, even grain that whittles nicely. It is also among the most durable of woods when exposed to decay-producing influences.

The Western red cedar is much like the Northern white cedar or arbor vitae, but is a larger tree and produces more red heartwood. At the present time, Western red cedar, in addition to supplying a considerable quantity of lumber, posts, and poles, furnishes nearly four fifths of all the shingles made in the United States.

The wood of the incense cedar is considerably heavier and stronger than that of the white or red cedar. In fact, in this respect it compares favorably with Southern yellow pine. Incense cedar wood is close-grained, and has a reddish, durable, heartwood useful for many purposes.

Port Orford cedar is a wood which is heavy, strong, and stiff. It has a good figure, and polishes well.

The Alaska or yellow cedar has perhaps the hardest wood of any of the so-called cedars. It is light, stiff, and strong, has a good figure, and takes a good polish.

Without distinction as to species, the factory uses of cedar in the United States are summarized in Table 74.

TABLE 74

FACTORY USES OF CEDAR

Purpose	Per Cent
Millwork	44
Professional and Scientific Instruments	20
Ship and Boat Building	7
Woodenware and Novelties	6
Caskets and Coffins	6
Laundry Appliances	5
Tanks and Silos	4
Furniture and Fixtures	3
Boxes and Crates	2
Other Uses	3
Total	100

In Table 74 the millwork—that is, the manufacture of sash, doors, blinds, interior finish, etc.—takes chiefly the Western cedars; while under the heading of professional and scientific instruments is included the Eastern red cedar used in pencil making. Smaller uses of Eastern red cedar are for:

Canes
Caskets
Chairs
Chests
Fixtures
Furniture
Interior finish
Musical instruments
Sash
Siding
Silos
Tanks
Umbrella handles
Vehicles
Woodenware

Uses reported for the Eastern white cedars are in the manufacture of:

Boat bottoms
Boat decking
Canoes
Cigar boxes
Dairymen's supplies
General millwork
Ice cream freezers
Interior finish
Oars
Pails
Planing mill products
Roof tanks
Rowboats
Shiplap
Siding
Signal devices
Silos
Tanks
Yachts

A Forest Service compilation lists the following uses for Western red cedar:

Barrel bungs
Battens
Blinds
Boards
Boats
- Cabins
- Canoes
- Ceiling
- Decking
- Finish
- Launches
- Planking
- Rails
- Roofs
- Skiffs
- Trim

Car construction
- Finish
- Roofing
- Siding
- Trim

Carving
Caskets
- Coffins
- Coffin boxes

Ceiling
Chests
Cigar boxes
Closet linings
Columns
Conservatories
- Sash
- Stands
- Trays

Cooperage
- Buckets
- Tubs

Cores
- Veneer

Decking
Doors
Drain boards
Drawing boards
Faucets
Finish
Fixtures
- Drawers
- Mirror backs
- Panels
- Shelves
- Show cases

Flooring
Flume stock
Framing
Furniture
- Bottoms
- Cabinets
- Drawer bottoms
- Frames
- Panels

Hot house trays
Incubators
Interior work
  Ceiling
  Finish
  Trim
Lath
Lattice
Lintels
Moldings
Organs (action)
Panels
Patterns
  Foundry
  Machine shop
Piano shanks
Pickets
Picture frames
Piling
Poles
Pontoon floats
Porch columns
  Built-up
  Turned
Posts
Sash
  Hot house
  Window
Scroll work
Shingles
Shiplap
Shop lumber
Siding
  Bevel
  Drop
Silos
Spigots
Spindles
Tanks
  Covers
  Staves
Tennis rackets
  Handles
Tent poles
Ties
Totem poles
Trays
  Fruit dryer
  Hot house
  Trunk
Turning
  Balusters
  Novelties
  Squares
Veneers (cores)
Washing machines
Window frames
Window sills

According to the Oregon reports, Port Orford cedar is used for boats (finish, frames, planking, skiffs), columns, fixtures, furniture (cabinets, moth-proof drawers, stools, tables), moth-proof chests, matches, sash and doors, and turnery.

Alaska or yellow cedar is used for boat cabins, interior finish, carvings, patterns, and pyrography. In addition to serving many other purposes, incense cedar is now being used for pencil making, because of the shortness of the supply of Southern red cedar.

CHERRY

The wild black cherry (*Prunus serotina*) is somewhat lighter in weight and a little softer than beech and birch; but it is nevertheless a dense, strong, hardwood of excellent wearing

qualities, and with a color and figure which make it highly prized in the manufacture of exceptionally fine furniture and interior finish. The supply is not large, and Table 75 indicates that nearly all the cherry is used for high-grade work.

TABLE 75

FACTORY USES OF CHERRY

Purpose	Per Cent
Furniture and Fixtures	24
Printing Material	17
Car Construction	16
Millwork	14
Professional and Scientific Instruments	6
Handles	5
Brushes	4
Musical Instruments	3
Clocks	3
Ship and Boat Building	2
Boxes and Crates	1
Patterns	1
Other Uses	4
Total	100

Specific uses reported for cherry are for:

Baskets
Beds
Boat finish
Bookcases
Brick molds
Brushes
Bushel crates
Butter dishes
Cabinets
Camera boxes
Card trays
Cars (finish)
Casing
Caskets
Chairs (posts, rounds)
Clock cases
Coffins
Collar trays
Counters
Desks
Doors
Dowels
Dressers
Flasks
Flooring
Electrotype blocks
Engraving blocks
Glove stretchers
Handles (duster brush)
Handles (saw)
Interior finish
Last blocks
Level blocks
Level sticks
Library furniture
Machine boxes
Musical instruments
Office fixtures

- Panels
- Partitions
- Parquetry
- Passenger cars
- Patterns
- Piano actions
- Piano cases
- Piano players
- Piano rails
- Picture moldings
- Pilot wheels
- Pipe organ (cases, actions)
- Plumbers' woodwork
- Plane handles
- Road machines (cabs, boxes)
- Sash
- School furniture
- Settees
- Shoe lasts
- Siding
- Spindle stock
- Spoons
- Store fixtures
- Swings
- Switchboards
- Tables
- Table drawers
- Table legs
- Tobacco pipes
- Trays (jewelry)
- Trim
- Woodenware

CHESTNUT

The wood of chestnut (*Castanea dentata*) is rather light, soft, and durable. It is easily worked, and appears well in furniture and fixtures, in many cases rather closely resembling white ash. The larger factory uses reported for chestnut are indicated in Table 76, but if the chestnut blight continues its uninterrupted progress, this useful wood will soon be a thing of the past in the United States.

TABLE 76

FACTORY USES OF CHESTNUT

Purpose	Per Cent
Millwork	28
Furniture and Fixtures	19
Caskets and Coffins	16
Musical Instruments	13
Boxes and Crates	12
Woodenware and Novelties	7
Other Uses	5
Total	100

Articles in which chestnut is used are:

- Boxes (cheese)
- Boxes (glass bottles)
- Boxes (handle)
- Boxes (meat)
- Brushes
- Cabbage crates
- Casing
- Casket molding
- Casket shells
- Casket tops
- Church pews
- Cores (veneer)
- Crating
- Doors
- Fence pickets
- Fence stubs
- Flooring
- Furniture (backs)
- Furniture frames (case goods)
- Furniture (kitchen)
- Ice chests
- Interior finish (house)
- Library tables
- Mantels
- Molding
- Outer cases (caskets)
- Panel work (house)
- Picture frames
- Pool table sides
- Refrigerators
- Ribs (poultry coops)
- Sash
- Siding
- Stair balusters
- Stair rails
- Stair rises
- Store and office partitions
- Veneer backing
- Wardrobes

COTTONWOOD

The cottonwoods or true poplars yield light, soft, even-grained, easily worked woods, more closely resembling basswood than any other species. Cottonwood, however, is tougher and stiffer than basswood, and, because of its interwoven fibers, resists wear extremely well for such a soft wood. The bulk of the cottonwood lumber is manufactured from the common Eastern cottonwood (*Populus deltoides*), which is most abundant in the lower Mississippi valley. In Oregon and Washington, the black cottonwood (*Populus trichocarpa*) yields a lumber which is used for the same purposes as that of the Eastern species.

Because of its lightness and strength, cottonwood is a favorite material with box makers, as will be seen from Table 77.

TABLE 77

Factory Uses of Cottonwood

Purpose	Per Cent
Boxes and Crates	56
Excelsior	14
Vehicles	9
Millwork	6
Agricultural Implements	4
Woodenware and Novelties	4
Furniture and Fixtures	2
Refrigerators and Kitchen Cabinets	1
Other Uses	4
Total	100

Particular uses reported for Eastern cottonwood are for:

Agricultural implements
Backs (washboards)
Baskets
Berry boxes
Bevel siding
Bookcases (inside work)
Boxboards (heavy vehicles)
Boxes
Boxes (manure spreaders)
Box shooks
Brooders (poultry)
Buggy backs
Car construction (rafters)
Car repairing parts
Carts
China closets
Clothboards
Coffins
Commodes
Corn binder parts
Corn shellers
Cornice
Cultivator parts
Cupboards (kitchen)
Crating
Dowels (chair)
Drawers
Drill boxes (farm implements)
Drills (farm implements)
Drop siding
Egg cases
Ensilage cutters
Envelope cutters
Eveners (harrow)
Fixtures (bar)
Fixtures (store and office)
Fodder shredders
Frames (canopy)
Furniture (inside work)
Incubators
Interior trimmings
Ironing-boards
Kitchen cabinets
Ladders
Manure spreaders (beds)
Millwork
Mortar boards
Music cabinets (inside work)
Packages (fruit and vegetable)
Panels (light vehicle bodies)
Panels (spring wagon bodies)
Piano cases (veneer cases)
Refrigerators
Saddle trees
Sample cases
Seeders, boxes (farm implements)
Self-feeders (threshing machines)
Separator sides (threshers)

- Shelving
- Shipping cases (butter)
- Siding (washboards)
- Stacker parts (farm machinery)
- Tables
- Trunks
- Vehicle bodies
- Vehicle seat backs
- Vending machines
- Wagon beds
- Wheelbarrows
- Woodenware

The Oregon or black cottonwood is used in Oregon and Washington for:

- Baskets
- Boxes
- Candy barrels
- Caskets
- Cores of veneered products
- Excelsior
- Farm machinery
- Fixtures, drawer bottoms, shelving)
- Furniture (chair seats, couch heads, drawer bottoms, shelving)
- Pack saddles
- Pulleys
- Trunks
- Veneer
- Woodenware

CUCUMBER

The tree commonly known as cucumber is one of the magnolias (*Magnolia acuminata*). The wood is soft, light, easily worked, durable, and very similar to yellow poplar, with which lumber much of it is marketed.

So far as separate uses are reported for cucumber, they are as indicated in Table 78.

TABLE 78

FACTORY USES OF CUCUMBER

Purpose	Per Cent
Millwork	50
Woodenware and Novelties	23
Boxes and Crates	18
Excelsior	6
Other Uses	3
Total	100

Cucumber enters into the manufacture of:

- Agricultural implements
- Cabinets
- Casing
- Casket trim
- Ceiling
- Cheese boxes (heads)

Doors	Partition
Flooring	Porch columns
Frames	Siding
Furniture	Stairs
Hay racks	Trim
Molding	Tubs
Pails	

CYPRESS

Cypress (*Taxodium distichum*) is one of the stronger and heavier softwoods, which, with the exception of greater weight, perhaps resembles redwood more closely than it does any other conifer. Cypress is one of the more durable woods; and some remarkable records of the longevity of cypress lumber and shingles are claimed by the manufacturers of this wood. Cypress works well, has a good figure, and a rich color in the red variety. The largest usefulness of cypress is in millwork, so far as factory purposes are concerned, as will be seen from Table 79.

TABLE 79

FACTORY USES OF CYPRESS

Purpose	Per Cent
Millwork	76
Boxes and Grates	6
Tanks and Silos	5
Caskets and Coffins	3
Machine Construction	2
Laundry Appliances	2
Woodenware and Novelties	1
Furniture and Fixtures	1
Other Uses	4
Total	100

Because of its durability, cypress is also much used for siding, shingles, railroad ties, and other purposes where it is exposed to decay-producing influences—among these latter uses being greenhouse construction.

The wide range of usefulness of cypress is indicated by the

following list of articles into the manufacture of which this wood enters:

Agricultural implements
Altars
Balusters (porch)
Baseboards
Beehives
Blinds
Boat parts
Boat siding
Bottoms (oil tanks)
Bottoms (water tanks)
Boxes
Butter tubs
Cabinets (ice cream)
Cabinet work
Candy pails
Carvings
Casing (house)
Casing (incubators)
Caskets
Churns
Cisterns
Cold frames (hotbeds)
Colonnades
Columns (porches)
Conservatories
Conveyors
Cornice
Covers (laundry machines)
Crating
Decking
Discs (laundry machines)
Door frames
Doors
Drawers (bottoms)
Drawers (ends)
Drawer sides (furniture)
Dropboards (poultry)
Dust arrester parts
Electric cars (interior work)
Feed mills
Finish (boats)
Fixtures (bank)
Fixtures (soda fountains)
Fixtures (store and office)
Flasks
Flour mills (machine parts)
Frames (vapor bath tubs)
Frames (window tents)
Grain elevators
Greenhouses
Hay baler parts
Hay loader parts
Hoppers (poultry houses)
Ice cream freezers
Incubator parts
Interior finish
Knifeboards (mowers)
Launch parts
Lodge furniture
Mantels
Musical instruments
Nests (poultry houses)
Pails
Panels (delivery wagons)
Panels (doors)
Panels (light vehicle bodies)
Patterns
Picture moldings
Porch work
Pumps
Refrigerators
Road rollers
Roof slats (light vehicle beds)
Sash (storm)
Screen doors
Siding
Signal devices
Silos
Spindles
Spraying apparatus
Stairwork
Starchers (laundry)
Staves (oil tanks)
Staves (water tanks)
Stepping
Store fronts
Tanks
Tanks (water closets)

- Towers (tanks)
- Trunks
- Tubs (laundry)
- Vats
- Vats (vinegar)
- Washers (hydraulic)
- Washing machines (hand)
- Water closets (unexposed parts)
- Water pipes
- Well machinery
- Well tubing
- Window frames
- Window screens
- Windmills
- Wringers (laundry)

DOGWOOD

Dogwood (*Cornus florida*) is very hard, heavy, close-grained, and wear-resistant, and is used in places where hard service would quickly destroy softer woods. As brought out elsewhere, the limited supply of dogwood is nearly all consumed in the manufacture of shuttles for the great cotton mills of the East.

Dogwood is also used to some extent for small handles, mauls, spindles, wedges, and mine rollers.

DOUGLAS FIR

Douglas fir (*Pseudotsuga taxifolia*) is an interesting timber because there is more of it than any other species in the United States, the greater proportion being in the northern Rocky Mountain and Pacific States. With the exception of redwood, Douglas fir trees are larger than any other in our forests; and they are capable of yielding timbers of practically any length and size desired.

The wood of Douglas fir is of medium weight, strength, stiffness, and toughness among the softwoods. It is used for the same general purposes as Southern yellow pine; and specifications for structural timbers often carry the two woods on the same basis.

More than half of the total output of Douglas fir lumber goes into general building operations and heavy construction. The more important factory uses reported are indicated in Table 80.

TABLE 80

FACTORY USES OF DOUGLAS FIR

Purpose	Per Cent
Millwork	87
Tanks and Silos	4
Car Construction	4
Ship and Boat Building	2
Pumps and Wood Pipe	1
Other Uses	2
Total	100

More specifically Douglas fir is used for:

Boats (beams, cabins, decking, finish, frames, keelsons, knees, masts, planking, spars, stems)
Boxes
Bridge timbers
Broom handles
Car construction
Cement pipe jackets
Columns
Crates
Crossarms
Decoy ducks
Dump cars
Elevator equipment
Fencing
Fixtures (backs, counters, facings, shelves)
Furniture (book cases, cabinets, chairs, cots, couch frames, drawers, kitchen and mission furniture, mirrors, spring frames, tables)
Foundry flasks
Gutters
Hop baskets
Interior work (casing, ceiling, finish, flooring, molding, stair work, veneered doors, wainscoting)
Ladders
Musical instruments
Panels
Patterns
Paving blocks
Pulleys
Refrigerators
Rug poles
Saddles
Sash and doors
Silo and tank stock
Slack and tight cooperage
Surveyors' stakes
Turnery
Veneer
Vehicles
Washing machines
Windmill parts
Wood stave pipe

ELM

There are several species of elm in the United States, by far the most abundant being the common or white elm (*Ulmus americana*). Other elms are rock or cork elm (*Ulmus racemosa*); slippery or red elm (*Ulmus pubescens*) cedar elm (*Ulmus crassi-*

folia) of the South; and wing elm (*Ulmus alata*), which is most common in Texas.

White elm is among the lighter of the hardwoods in weight, is not so strong as many of them, and is not very hard. It is, however, a tough, fibrous wood of varied usefulness. Rock elm is heavy, hard, tough, and strong; and ranks next to hickory for many purposes, especially in the line of vehicle manufacture. Slippery elm is somewhat darker in color than white or rock elm, and is about midway between these two woods in mechanical properties. Wing and cedar elm are used for the same general purposes as white elm.

The statistical reports do not distinguish between the various elms. The combined uses are summarized in Table 81.

TABLE 81

FACTORY USES OF ELM

Purpose	Per Cent
Boxes and Crates	29
Furniture and Fixtures	19
Vehicles	14
Woodenware and Novelties	7
Musical Instruments	7
Refrigerators and Kitchen Cabinets	6
Agricultural Implements	3
Trunks and Valises	3
Millwork	3
Sporting and Athletic Goods	1
Handles	1
Other Uses	7
Total	100

Uses reported for white elm are:

Automobile bodies
Automobile doors
Bails
Banana hampers
Baskets
Basket handles
Bicycle rims
Billiard tables
Bobsleds
Boxes
Bushel measures
Cant-hook handles
Canoe-boat bottom boards
Chairs
Chair bottoms
Cheesebox rims
Communion tables
Crating
Cultivators
Doubletrees

Drawstops
Eveners
Fish backs
Flooring
Folding machines
Grapples
Hand sleds
Hoops (coiled)
Hose menders
Hubs
Ice chests
Interior finish
Kitchen cabinets
Ladders
Mission furniture
Pails
Peavy handles
Pews
Pianos
Pikepoles
Potato crates
Power-pump skids
Press racks
Printers' cabinets
Pulpits
Refrigerators
Riddle rims
Roll-paper cutters
Root cutters
Seed cabinets
Shipping baskets
Showcases
Sieve rims
Singletrees
Sleigh runners
Spraying machines
Stone boats
Store fixtures
Tanner liquor logs (pipe)
Toys
Trunks
Tubs
Wall cases
Washboards
Washing-machine parts
Waste baskets
Wheelbarrows
Woven boxes

Rock elm is used in the manufacture of:

Agricultural implements
Automobile bodies and seats
Bails
Bentwood
Boxes
Crating
Doubletrees (plow and harrows)
Dowels
Eveners (plow and harrow)
Feed cutters
Handles
Hay loader parts
Hounds (vehicles)
Hoppers
Horizontal bars
Hubs (light vehicle wheels)
Interior finish
Ladders
Machine handles
Platforms
Posts (seat)
Rims (trucks)
Rockers (chairs)
Singletrees
Sleigh runners and bodies
Stirrups
Trunks
Trunk slats
Wheelbarrows

EUCALYPTUS

The eucalyptus family is a native of Australia. A number of species were early introduced into California, and more re-

cently considerable plantations of eucalyptus have been establishd in that state. The one commonly planted is the blue gum (*Eucalyptus globulus*), although the wood of this species is said to have fewer desirable qualities than that of some other less widely planted eucalyptus.

Eucalyptus wood is generally very hard, heavy, tough, and strong, even surpassing hickory in some respects. However, it is much more difficult to season without serious warping and checking than is any other wood used in this country. Much of this difficulty is apparently due to the fact that practically all the eucalyptus lumber so far manufactured in the United States is necessarily produced from young trees of extremely rapid growth. The wood of the large, mature, native Australian eucalyptus is said to work much better than that from the young planted trees in this country.

Unfortunately, unscrupulous promoters whose object has been to sell stock in eucalyptus companies have disseminated a vast amount of misleading information about the properties of the wood and the fabulous returns to be expected from eucalyptus plantations. Only a small amount of eucalyptus lumber is manufactured, and the uses for it are chiefly as shown in Table 82.

TABLE 82

FACTORY USES OF EUCALYPTUS

Purpose	Per Cent
Ship and Boat Building	80
Vehicles	12
Agricultural Implements	3
Furniture	2
Millwork	1
Machine Construction	1
Other Uses	1
Total	100

FIR

Under this heading are grouped the true firs of the botanical genus *Abies*. Douglas fir, which is known by a wide variety of names, is a distinct genus, and not a fir at all; neither does it have much in common with the true firs since it is much heavier and stronger than these woods.

Of the various true firs, the most important are the balsam fir (*Abies balsamifera*) of the Northern States; the white fir (*Abies concolor*) of the Rocky Mountain and Pacific Coast region; the Alpine fir (*Abies lasiocarpa*), which grows in high altitudes in the Western mountains; the noble fir (*Abies nobilis*), which is most abundant in Oregon; and the red fir (*Abies magnifica*) of California. The balsam fir of the East, and the Alpine fir of the West, are small trees of very similar character. The white, noble, and red firs are among the large trees of the regions in which they are found. The wood of all the firs is very light in weight, soft, not strong, brittle, and even-grained, with no great variations in texture. The firs are not largely sawed at present. Fir lumber is chiefly used for boxes and crates, for which purpose the light weight and softness especially fits these woods. The firs also furnish much material for wood pulp.

So far as reported, the factory uses of the firs are summarized in Table 83.

TABLE 83

FACTORY USES OF FIR

RED FIR

Purpose	Per Cent
Boxes and Crates	72
Millwork	28
Total	100

ALPINE FIR

Purpose	Per Cent
Boxes and Crates	62
Millwork	33
Excelsior	3
Other Uses	2
Total	100

BALSAM FIR

Purpose	Per Cent
Boxes and Crates	76
Millwork	20
Car Construction	1
Refrigerators and Kitchen Cabinets	1
Woodenware and Novelties	1
Other Uses	1
Total	100

WHITE FIR

Millwork	72
Boxes and Crates	27
Other Uses	1
Total	100

The noble fir is used for the same general purposes as are the other true firs.

Uses reported for balsam fir include:

Boxes
Boxes (herring)
Cases
Cases (packing)
Cases (sardines)
Ceiling
Clapboards
Cloth boards
Crates
Dairy supplies
Flooring
Frames (door)
Frames (window)
Ironing-table tops
Molding
Refrigerators
Sash
Sheathing
Shooks
Siding
Suit-case frames
Trim

BLACK GUM

Black gum (*Nyssa sylvatica*), although generally called gum, is in no way related botanically to red gum. It is a member of the same genus as tupelo, and much of it is included in the statistics of that wood.

Black gum is somewhat heavier than red gum. The wood is moderately strong and stiff, tough, and very difficult to split —properties which are often desirable. Separate uses reported for black gum are in the manufacture of:

Baskets
Berry cups
Boxes
Conduits
Chucks
Hoppers
Hubs
Keels
Lard dishes
Mauls
Mine rollers
Paving blocks
Ox yokes
Reshippers (bottle crates)
Rollers (boats)
Rug poles
Table legs
Veneer barrels

RED GUM

Red gum (*Liquidambar styraciflua*) is one of the softer hardwoods of medium weight and strength. It has a good figure and a reddish heartwood that make it useful for many purposes. Red gum works easily and is fairly tough; so the lower grades are in large demand for boxes and crates; while the figured wood, properly stained, gives perhaps the closest duplication of Circassian walnut obtainable with any timber. Stained differently, red gum is also much used to give mahogany effects.

In addition to being the wood most largely used for slack barrel staves and heading, the statistical reports give the information embodied in Table 84, upon the factory uses of red gum.

TABLE 84

FACTORY USES OF RED GUM

Purpose	Per Cent
Boxes and Crates	50
Millwork	15
Furniture and Fixtures	15
Vehicles	3
Pulleys and Conveyors	2
Sewing Machines	2
Refrigerators and Kitchen Cabinets	2
Agricultural Implements	1
Musical Instruments	1
Woodenware, Novelties, etc.	1
Picture Frames and Moldings	1
Other Uses	7
Total	100

Red gum and sap gum (the sapwood of red gum) enter to some extent into the manufacture of the following articles:

Alfalfa grinder parts
Ballot boxes
Barrels (veneer)
Baskets (fruit)
Baskets (vegetable)
Berry cups
Bookcases (exterior work)
Bottom boards (piano)
Bottoms (heavy vehicle seats)
Boxboards (dump carts)
Boxes
Boxes (delivery wagons)
Boxes (veneer)
Boxes (wire bound)
Box shooks
Brush blocks

Cabinets
Carvings
Caskets
Casing
Cattle guards (railway cars)
Chair frames (upholstered furniture)
Chairs
Chairs (folding)
Chairs (kitchen)
Chairs, official (lodge furniture)
Chairs (parlor)
Cheese boxes
China closets (extension)
Cigar boxes
Cigar wheels (wheel-of-chance)
Coffee drums
Columns (porch)
Commodes
Consoles
Cooperage stock (slack)
Cooperage stock (tight)
Corn graders
Cradles
Crates (fruit and vegetable)
Crating
Cultivator handles
Cupboards (backing)
Cupboards (kitchen)
Curtain poles
Desks (house)
Desks (office)
Dining tables
Drawer bottoms
Dressers (exterior)
Egg cases
Elevator cars
Eraser blocks (blackboard)
Fanning mills
Faucets
Fixtures (bank)
Fixtures (soda fountains)
Fixtures (store and office)
Flour mills (machinery parts)
Folding beds
Frames (couches)
Frames (davenports)
Frames (lounges)
Furniture (exposed)
Furniture (interior work)
Game traps
Grain weighers
Guitar bodies
Handles
Handrails (stairwork)
Hay-baler parts
Hobby horses
Interior finish
Ironing boards
Kitchen cabinets
Kitchen cabinets (backing)
Lawn swings
Legs (incubator)
Library cases
Lining (inside coat boxes)
Litter carrier parts
Manure spreaders
Mop handles
Moldings (piano)
Music cabinets (exterior)
Neck yokes (cultivator)
Ornaments (furniture)
Packages (vegetable)
Panels (light vehicle bodies)
Panels (veneered)
Parlor cabinets (inside work)
Pedestals
Pens
Piano benches
Picture moldings
Posts (stairworks)
Reed organs (interior parts)
Reed organs (exterior)
Refrigerators
Reshippers (boxes)
Rims (guitars)
Runners (sleighs and sleds)
Saddletrees
Sandboards (heavy vehicles)
Scale parts (platform scale)
Screen doors
Seats (water closets)
Seed-cleaner parts
Self-feeders (threshing machines)
Sewing machine parts

Fig. 83.—A Dense Stand of Longleaf Pine.

Sideboards (built in)
Sideboards (exterior work)
Sideboards (interior work)
Signs (advertising)
Singletrees (cultivators)
Small gun stocks
Sofa frames (upholstered furniture)
Spigots
Stepping (stairwork)
Tables
Tables (extension)
Tables (kitchen)
Tables (library)
Tabourets
Tanks (water closets)
Thresher parts
Tight cooperage stock
Trimmings (piano)
Trunks
Type cabinets
Vano slats (windmill)
Vehicle bottoms
Vending machines
Vending machines (matches)
Veneer cores
Veneer doors
Wardrobes (exterior work)
Wardrobes (interior work)
Washboards (laundry)
Washing machine parts
Weather strippings
Wheel slats (windmill)
Window screens
Woodenware

HACKBERRY

Hackberry (*Celtis occidentalis*), although not an abundant forest tree, has a wide range; and small quantities are manufactured into lumber and also into cooperage. The wood is heavy, moderately hard, strong, and tough. In properties it is most like white elm, while in appearance the lumber resembles ash.

Statistical reports do not distinguish between the ordinary hackberry and the Southern form or sugarberry (*Celtis mississippiensis*).

TABLE 85

FACTORY USES OF HACKBERRY

Purpose	Per Cent
Millwork	39
Boxes and Crates	28
Woodenware and Novelties	13
Vehicles	9
Furniture and Fixtures	7
Saddles and Hames	4
Total	100

FIG. 84.—Mature Western Yellow Pine.

FIG. 85.—Large, Clear White Pine Logs.

TIMBER SCENES

Specific uses reported for hackberry include:

Buggy bodies	Rakes
Cart trees	Saddle trees
Farm implements	Stair rails
Handles	Steps
Furniture	Table legs and tops
Hoe handles	Tubs
Interior finish	Wagon parts
Kegs	

Louisiana factories use sugarberry for:

Car finish	Stair steps
Furniture	Table frames
Railing	Tool handles
Slack cooperage	Vehicle bodies

HEMLOCK

Commercially, there are two important species of hemlock—the Eastern hemlock (*Tsuga canadensis*), which is most abundant in the Lake States, West Virginia, Pennsylvania, New York, and New England; and Western hemlock (*Tsuga heterophylla*), the largest stands of which are in the Pacific Northwest.

The Eastern hemlock is among the lighter woods in weight, fairly stiff and strong, and tougher than most softwoods. The Western hemlock is heavier, stronger, and stiffer than the Eastern, and, in mechanical properties, rather closely approaches Douglas fir. A large proportion of the hemlock lumber goes directly from the sawmill into general building operations.

Without distinction between species, the reports indicate the factory uses of hemlock as given in Table 86.

TABLE 86

FACTORY USES OF HEMLOCK

Purpose	Per Cent
Millwork	62
Boxes and Crates	29
Car Construction	2
Furniture	1
Trunks and Valises	1
Refrigerators and Kitchen Cabinets	1
Other Uses	4
Total	100

More specifically, Eastern hemlock enters into the manufacture of the following articles:

- Bakers' machinery
- Beamboxes (weighing machines)
- Boat parts
- Boxes
- Car decking
- Car doors
- Crating
- Flasks
- Flooring
- Ice boxes
- Interior finish
- Pails
- Piano boxes
- Portable farm forges
- Refrigerators
- Sash
- Seed boxes (machines)
- Shop patterns (boats)
- Siding
- Signs
- Silos
- Tobacco cases
- Trunks
- Tubs
- Vehicles
- Washboards
- Well machine parts
- Window frames

According to the Oregon and Washington reports, Western hemlock is used on the Pacific Coast for:

- Boat finish
- Boxes
- Caskets
- Cooperage
- Crates
- Fixtures (drawers, shelves)
- Furniture (backing, couches, kitchen table tops)
- Interior work (casing, ceiling, finish, flooring, molding, wainscoting)
- Pulp
- Sash and doors
- Screens and veneer

HICKORY

There are a number of species of hickory; but those of greatest commercial importance are five, as follows: Shellbark (*Hicoria laciniosa*), shagbark (*Hicoria ovata*), mockernut (*Hicoria alba*), bitternut (*Hicoria minima*), and pignut (*Hicoria glabra*). The pecan (*Hicoria pecan*) is also a hickory, and is used to some extent for the same purposes as the other species.

The hickories, with the exception of black locust and osage orange, are the heaviest, strongest, and toughest of our native woods. It is the remarkable toughness of hickory, and its ability to withstand shocks, that make it the wood above all others for vehicle work.

All the hickories are used in the manufacture of vehicles, handles, and other articles where strength and toughness are the main consideration; but pignut perhaps possesses these properties in greater degree than any of the other species.

The factory uses of hickory are indicated in Table 87.

TABLE 87

FACTORY USES OF HICKORY

Purpose	Per Cent
Vehicles	61
Handles	31
Agricultural Implements	3
Sporting and Athletic Goods	1
Other Uses	4
Total	100

A great deal of hickory, instead of being manufactured into lumber, goes in bolt form directly to the factory in which it is to be fashioned into some useful article. According to the reports, hickory enters more or less into the construction of:

Agricultural implements
Axles (light vehicles)
Baskets
Baseball bats
Binder parts
Board rules
Bottoms (wagon boxes)
Brake bars
Cabinet work
Calking hammers
Canes
Car repairing
Car construction
Carvings
Chairs
Corn binder parts
Crossbars (light vehicles)
Crutches
Cultivator handles
Doubletrees
Dowels
Eveners (farm implements)
Felloes
Freight cars
Gear woods (light vehicles)
Golf sticks (handles)
Hammer handles
Handles
Handles (broom)
Handles (edge tools)
Hay baler parts
Hay loader parts
Header parts
Hounds (heavy vehicles)
Ladders
Ladder rungs
Log rules
Machinery handles
Mallets
Manure spreader parts
Maul handles
Molds (brick)
Neck yokes (implement)
Neck yokes (plows)

Neck yokes (vehicles)
Patterns
Pike poles
Pins
Picture molding
Picker sticks
Pick handles
Pitmans (farm implements)
Plow beams
Plow handles
Poles (light vehicle)
Rake teeth
Refrigerators
Revolving rakes
Rims (automobile wheels)
Rims (vehicle wheels)
Road-scrapers
Shafts (vehicle)
Singletrees
Sledge handles
Small tool handles
Spokes (automobile)
Spokes (light and heavy vehicles)
Spring bars (light vehicles)
Sucker rods
Threshing machines
Tongues (light vehicles)
Tongues (wagon)
Tongues (wheel scrapers)
Trapeze (gymnasium)
Trucks
Trunk slats
Turnings
Wagon stock
Wagon jacks
Whiffletrees
Windmill rods

HOLLY

Holly (*Ilex opaca*) is a tough, close-grained wood of ivory-like appearance, which makes it especially valuable for inlay work and in the manufacture of many small articles. Since holly trees are neither large nor abundant, only small quantities of this wood are available. The factory uses reported are indicated in Table 88.

TABLE 88

Factory Uses of Holly

Purpose	Per Cent
Woodenware and Novelties	69
Brushes	24
Musical Instruments	4
Other Uses	3
Total	100

HORNBEAM

Hornbeam or ironwood (*Ostrya virginiana*) is one of the heaviest, hardest, and toughest American woods, ranking very closely to the hickories in these respects. It is not available in such large quantities as the hickories, but is used for much the same purposes, as Table 89 indicates.

Specific uses for hornbeam includes axles, felloes, tongues, levers, canes, umbrella sticks, and whipstocks.

TABLE 89

Factory Uses of Hornbeam

Purpose	Per Cent
Handles	68
Vehicles	21
Millwork	3
Furniture	2
Woodenware and Novelties	2
Other Uses	4
Total	100

LARCH

See Tamarack (page 308).

LAUREL

Laurel (*Kalmia latifolia*) is a fine-grained hardwood, produced in small quantities in the Southern mountains. It is nearly as hard as dogwood, and as heavy as white oak. It is not available in large sizes nor in great quantity, and is known as kalmia in the manufacture of tobacco pipes.

The California laurel (*Umbellularia californica*), or myrtle, is not very abundant, but is used on the Pacific Coast in boat building and for the manufacture of interior finish, fixtures, furniture, pilot wheels, turnery, and novelties as shown in Table 90.

TABLE 90

Factory Uses of Laurel

Purpose	Per Cent
Ship and Boat Building	66
Furniture and Fixtures	19
Brooms and Carpet-Sweepers	7
Woodenware and Novelties	6
Millwork	2
Total	100

LOCUST

There are two native locusts found in the Eastern states—the honey locust (*Gleditsia triacanthos*) and the black locust (*Robinia pseudacacia*). The honey locust is not abundant, however; and so, while possessing many desirable qualities in the way of strength and hardness, is little used.

Black locust and osage orange closely compete for the honor of being the heaviest and strongest American woods. In other respects they split even, for osage orange is the tougher, and black locust the stiffer. Both shrink less in seasoning than almost any other wood, either hard or soft—which is also an extremely desirable quality.

Black locust finds by far its largest use in the manufacture of insulator pins and brackets, with a small amount used for millwork, in ship and boat building, and for vehicles. In ship and boat building, black locust is valuable for treenails, for the ancient method of holding two pieces of wood together by means of a wooden pin or nail has, for some purposes, not been improved upon.

TABLE 91

FACTORY USES OF LOCUST

Purpose	Per Cent
Insulator Pins and Brackets	90
Millwork	3
Ship and Boat Building	3
Vehicles	2
Other Uses	2
Total	100

Black locust is also used for patterns, chucks, hubs, turnery, trunnels, and spokes for boat wheels.

Some of the small amount of honey locust manufactured is used in furniture, millwork, balusters, newels, and molding.

MAGNOLIA

Two species of magnolia are cut for lumber to some extent in the Southern states, in addition to the cucumber tree previously mentioned. These are the evergreen magnolia (*Magnolia*

foetida) and the sweet magnolia (*Magnolia glauca*) or bay tree. Most of the magnolia lumber, however, is made from the evergreen magnolia.

Magnolia wood is of compact structure, light, soft, easily worked, with a satiny luster, and creamy white to light brown in color. It goes to market with yellow poplar, as well as under its proper name. Such separate factory uses of magnolia as are reported are shown in Table 92.

TABLE 92

FACTORY USES OF MAGNOLIA

Purpose	Per Cent
Boxes and Crates	88
Furniture and Fixtures	8
Millwork	2
Tobacco Boxes	1
Other Uses	1
Total	100

More specific uses reported for magnolia include:

Bed-room suites
Boats
Boxes
Broom handles
Brushes
Cabinets
Car sheathing
Cotton gins
China closets
Door panels
Dressers
Egg cases
Excelsior
Furniture
Interior finish
Molding
Ox yokes
Sash
Tables
Wagon boxes
Wash stands

MAPLE

Four species of maple are of commercial importance from the lumber standpoint. These are hard or sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), soft or silver maple (*Acer saccharinum*), and Oregon maple (*Acer macrophyllum*). Hard maple is by far the most abundant and useful member of the group.

The wood of hard maple is of moderate weight for a hardwood, strong, hard, and with good wearing qualities. Variations

in structure and appearance due to peculiarities of growth give curly and bird's-eye effects which are much prized. The wood of soft maple is considerably lighter in weight, and not so strong or stiff as that of the hard maple. It has a good figure, and is used for many purposes. Red maple is about midway between hard and soft maple in weight and strength. In hardness, it is close to the soft maple; and in stiffness, not very far from the hard maple. Oregon maple is the only commercial maple on the Pacific Coast, and is the most important hardwood of that region. The wood resembles that of the Eastern maples, and is used for the same general purposes.

Hard maple is the maple used in the manufacture of hardwood flooring and wherever strength and resistance to wear are the determining qualities.

In the wood-using industry reports, all the maples are grouped together with results shown in Table 93.

TABLE 93

FACTORY USES OF MAPLE

Purpose	Per Cent
Millwork	34
Furniture and Fixtures	17
Boxes and Crates	10
Boot and Shoe Findings	6
Agricultural Implements	5
Musical Instruments	5
Handles	4
Woodenware, Novelties, etc.	4
Vehicles	4
Laundry Appliances	2
Other Uses	9
Total	100

These specific uses reported for hard maple indicate the great serviceability of this wood:

Automobile benches
Automobile bottoms
Automobile gears
Automobile sub-floors
Axles
Baggers
Baseball bats
Baskets
Bean pickers
Bicycle rims
Billiard cues
Billiard rings

Blueprint frames
Bobbins
Bobsleds
Bolsters
Bowling alleys
Bowls
Boxes
Bread boards
Brewers' chips
Broom handles
Brush backs
Brush handles
Built-up panels
Butcher blocks
Butter boxes
Butter ladles
Butter molds
Cameras
Canes
Cant-hook handles
Car-gallows frames
Carpet-sweepers
Carrom cues
Carrom rings
Caster rollers
Cattle guards
Center wheels
Chair bottoms
Chair rods
Checkers
Churn dashers
Clothespins
Coat hangers
Coil bases (telephone)
Corn huskers
Corn planters
Corn shellers
Costumers
Cot frames
Cranes
Croquet balls
Croquet mallets
Culm pipe (mines)
Cultivator handles
Curtain poles
Dashboards
Die blocks
Die cases
Dishes
Dominoes
Door knobs
Dowels
Drawer bottoms
Dumb-bells
Electrotype blocks
Ensilage cutters
Extension stretchers
Factory trucks
Faucets
Feed cutters
Feeders
Flooring
Furniture
Games
Gas-engine skids
Girts
Go-carts
Grain doors
Grain separators
Grills
Guitars
Hand cars
Handles
Handspikes
Hay balers
Hay pressers
Hoop drums
Horizontal bars
Hose menders
Indian clubs
Interior finish
Kitchen cabinets
Knobs (furniture)
Kraut cutters
Ladders
Lasts
Lemon squeezers
Levers
Log cars
Mallets
Mandolins
Mangle rollers
Manual training supplies
Manure spreaders

Meat boards
Medicine cabinets
Mission furniture
Office fixtures
Packing-house cutting tables
Paddles
Pails
Paper cutters
Parasol handles
Parquetry floors
Patterns
Peavy handles
Pianos
Piano bridges
Piano pin planks
Piano players
Plow beams
Plugs
Plumbers' woodwork
Porch swings
Portable sawmills
Potato mashers
Potato planters
Pulley spokes
Pumps
Push cars
Racks
Railroad velocipedes
Reed furniture (rods)
Refrigerators
Riddles
Road rollers
Roller pins
Rules
Sawmill machinery
Scythe snaths
Self feeders
Separators (grain)
Sheeting
Showcases
Shredders
Skewers
Sleighs
Spindles
Spoke wedges
Spool barrels
Spoons
Steak mauls
Steering wheels
Stonecutters' mallets
Stone boats
Store fixtures
Switch boards
Table rims
Talking machines
Tanks
Tanning drums
Tenpins
Threshing machines
Thresholds
Tie plugs
Timber grapples
Tinners mallets
Tin-plate boxes
Toothpicks
Towel racks
Toys
Track gauges
Track levels
Trucks
Trunks
Tubs
Type cabinets
Type cases
Umbrella racks
Wall cases
Wall clocks
Washboards
Washing machines
Weighing machines
Wheelbarrows
Wind stackers
Wooden bearings
Wood knobs (grilles)
Woodtype
Yardsticks

Soft maple is used in the manufacture of:

Auto frames
Baby carriages
Ballot boxes
Berry baskets

Boats
Bookcases
Boxes
Brooders (poultry)
Broom handles
Butter bowls
Carpet sweepers
Chairs
Coat hangers
Corn planters
Cot frames
Cradles
Cultivators (garden)
Door frames
Egg cases
Extension-table sides
Fanning mills
Filing cabinets
Fixtures
Flooring
Furniture
Grass seeders
Hall clocks
Hay racks
Hand sleds
Ice boxes
Incubators
Interior finish
Ironing boards
Kitchen cabinets
Knobs (furniture)
Lap boards
Lawn swings
Manual training supplies
Music cabinets
Office fixtures
Parquet floors
Pianos
Piano benches
Pumps
Potato planters
Reels (wire)
Refrigerators
Root cutters
Signs
Sleeve boards
Table tops
Tabourettes
Tin-plate boxes
Umbrella racks
Vehicles
Velocipedes, railroad
Wardrobes
Woodenware

Oregon maple is used on the West Coast for:

Baskets
Boat finish
Building rollers
Dollies
Fixtures (counter tops, grill work, mirrow frames, show cases)
Furniture (bookcases, chairs, davenport frames, school furniture, spindles, tables)
Handles
Interior work (finish, flooring)
Pulleys
Saddles
Tent toggles
Trunk slats

OAK

Botanists recognize some fifty species of oak in the United States, all but a few of which attain tree size, while many are among the largest and finest hardwoods. With such a wealth of species, it is impossible to get statistics upon the consumption of the separate kinds with any degree of accuracy. Moreover,

most of the oak is marketed under the general names of white oak or red oak, without further specific distinction.

Of the white oak group, the most important are the true white oak (*Quercus alba*), bur oak (*Quercus macrocarpa*), post oak (*Quercus minor*), cow oak (*Quercus michauxii*), chestnut oak (*Quercus prinus*), chinquapin oak (*Quercus acuminata*), overcup oak (*Quercus lyrata*), and Oregon oak (*Quercus garryana*). Of the red oak group, the most useful species are the true red oak (*Quercus borealis*), Texan oak (*Quercus Texana*), yellow oak (*Quercus velutina*), scarlet oak (*Quercus coccinea*), turkey oak (*Quercus catesbaei*), Spanish oak (*Quercus digitata*), pin oak (*Quercus palustris*), shingle oak (*Quercus imbricaria*), and willow oak (*Quercus phellos*). The white and red oak groups supply about equal amounts of lumber. Two other important species which belong to neither group are live oak (*Quercus virginiana*) and California tanbark oak (*Quercus densiflora*).

The wood of nearly all the oaks is heavy, hard, strong, and tough, with the characteristic figure which has always made oak a standard cabinet, furniture, finish, and flooring wood, in addition to its great usefulness for vehicles and in other places where strength is essential.

There is, of course, considerable variation in the strength, hardness, stiffness, weight, and other properties of the oaks, as is shown in the chapter upon the properties of wood. Among all the oaks, the live oak leads in strength, hardness, and toughness. In the days of wooden ships, it was especially in demand. The supply of live oak timber is much less than that of many other oaks; and at present but little is manufactured into lumber.

Without regard to species, the factory uses of oak are summarized in Table 94.

TABLE 94

FACTORY USES OF OAK

Purpose	Per Cent
Furniture and Fixtures	32
Millwork	25
Car Construction	15
Vehicles	11
Agricultural Implements	3
Boxes and Crates	3
Ship and Boat Building	2
Refrigerators and Kitchen Cabinets	2
Musical Instruments	1
Sewing Machines	1
Other Uses	5
Total	100

The many specific uses for white oak are illustrated by the following list of articles in which this wood is used in the factories of Illinois:

Altars (church)
Art lamps
Axe handles
Backgrounds (display windows)
Ball racks (pool and billiard)
Balusters
Barber chairs
Barber furniture
Bar fixtures
Bars (wooden harrows)
Baseboards
Basket parts
Beams (plow)
Beds
Beds (cot)
Beds (folding)
Billiard (tables)
Binder parts
Boat parts (row)
Bobsleds
Bolsters (heavy vehicles)
Bookcases
Book racks
Bottoms (baggage trucks)
Bottoms (delivery wagons)
Braces (railway car frames)
Brackets
Brake beams (heavy vehicles)
Brush blocks
Buffets (exterior)
Bumping posts (railroad)
Butter churn bodies
Butter churn bottoms
Cabinets (dental)
Cabinets (filing)
Cabinets (music rolls)
Cabinets (parlor)
Cabinets (phonograph records)
Cabinets (toilet)
Cabinets (towels)
Cabins (boats)
Capitals
Card tables
Cases (medicine)
Cases (railroad ticket)
Casing
Caskets
Chair frames

Chairs
Chairs (adjustable)
Chairs (invalid)
Chairs (office)
Chairs, official (lodge room)
Chairs (rolling)
Chairs (stenographers)
Cheval mirrors
Chiffoniers
China closets
Church pews
Cigar wheels (wheel-of-chance)
Clay gatherers (machine parts)
Cleats (wagon boxes)
Coffins
Colonnades
Columns (porch)
Consoles
Cores (veneer doors)
Corn binders
Corn grinders
Costumers
Couches (folding)
Counters (bar)
Counters (store)
Cradles
Cue racks (pool and billiard)
Cultivator handles
Desks (electric switchboards)
Desks (house)
Desks (office)
Disc drill parts
Disc harrow parts
Door frames (box cars)
Doors
Doubletrees (farm implements)
Doubletrees (vehicle)
Drags (farm implements)
Dressers
Dressing tables
Drill parts (farm implements)
Drum lagging (hoisting engine)
Edge-tool handles
Electric cars (interior finish)
Elevator cages
Eveners (farm implements)
Felloes
File cases
Finish (boats)
Fixtures (bank)
Fixtures (barbershop)
Fixtures (display window)
Fixtures (laboratory)
Fixtures (soda fountain)
Fixtures (store and office)
Flooring (hardwood)
Folding beds
Folding screens
Frames (couches)
Frames (davenports)
Frames (dummy carts)
Frames (electric cars)
Frames (freight cars)
Frames (light vehicle bodies)
Frames (lounges)
Frames (motor boats)
Frames (upholstered furniture)
Frames (vessels)
Frames (windows)
Furniture
Gear woods (light vehicle)
Grilles
Guitar bodies
Hall racks
Hammer handles
Handles
Hand rails (stairwork)
Harrows
Hatracks
Hay baler parts
Hayrake parts
Horse powers
Hounds
Hubs (heavy vehicle wheel)
Hulls (boats)
Hydraulic jacks
Interior finish
Keels (boats)
Keels (motor boats)
Keyracks
Kitchen cabinets (exterior)
Kitchen cupboards
Kitchen safes
Ladders (gymnasium)

Launch parts
Lawn swings
Leaves (table)
Legs (piano)
Library cases
Lodge furniture
Machine handles
Mandolin bodies
Mantels
Manure spreaders
Merry-go-round parts
Mirror cases
Mission furniture
Molding (house trimming)
Molding (piano)
Molding (stairwork)
Mug cases (barbershop)
Music cabinets
Necktie racks
Newels
Oil well machine frames
Organ cases
Ornaments (furniture)
Outer cases (caskets)
Panels (veneered)
Paper racks
Parallel bars
Parlor cabinets (exterior)
Parlor rockers
Parquetry flooring
Passenger cars (frames)
Passenger cars (interior finish)
Pedestals
Pedestals (tables)
Pew racks
Piano benches
Piano cases
Piano chairs
Piano players (exterior)
Piano stools
Pick handles
Picture moldings
Pilasters (piano)
Plate racks
Plow beams
Plow handles
Plow rounds
Plow parts (gang)
Plows
Poles (light vehicles)
Pool tables
Posts (railway car frames)
Posts (stairwork)
Pulpits (church)
Racks (hat and coat)
Reaches (heavy vehicles)
Reels (electric light wire)
Refrigerators
Revolving chairs (office)
Revolving chairs (parlor cars)
Rims (heavy vehicle wheels)
Risers (stairwork)
Road-scrapers
Rocker frames (upholstered furniture)
Sand boards
Sash
Screen doors
Seats (water closets)
Sections (wheel-scrapers)
Seeder parts (farm implements)
Serving tables
Sewing tables
Shanks (cultivators)
Shells (drum)
Sideboards (built in)
Sideboards (exterior)
Siding (boats)
Sills (threshers)
Singletrees (cultivators)
Singletrees (vehicle)
Sleds (toy)
Sofa frames (upholstered furniture)
Somnols
Spokes (heavy vehicles)
Spring bars
Spring blocks (Ry. tank cars)
Stacker parts (farm machinery)
Stands
Stands (jardinieres)
Stands (lamps)
Staves (water tanks)
Steps (stairwork)
Stringers (railway cars)

Subscriber sets (telephone)
Sulky plow parts
Sweeps (farm machinery)
Sweeps (windmills)
Switchboards (telephone and telegraph)
Tables (café)
Tables (dining)
Tables (extension)
Tables (library)
Tables (parlor)
Tables (typewriter)
Tables (writing)
Tabourets
Tanks (brewery)
Tanks (distilling)
Tanks (water closets)
Telephones
Threshing machines
Tight cooperage stock
Tongues (wheel-scrapers)
Tool chests
Tool handles
Trays (jewelry)
Type (cabinets)
Typewriter cabinets
Umbrella stands
Vats (distilling)
Vats (oil)
Vending machines (matches)
Vending machines (peanuts)
Vestment cases (church)
Wagon boxes
Wainscoting
Wall cases
Wardrobes (exterior)
Washstands
Water gates
Water wheels
Well-digging machines
Windmill parts
Window screens

The red oaks are used in the manufacture of:

Agricultural implements
Art lamps
Back grounds
Balusters
Barber furniture
Barrow boxes
Baskets
Beds
Bentwood
Billiard tables
Boats
Bob sleds
Bolsters
Bottoms (wagon)
Boxes
Brackets
Brake bars
Bucket staves
Buggy bows
Cabinets
Cabin parts
Car construction
Cars (mine)
Car repairing
Casing (building)
Caskets
Chair frames (upholstered furniture)
Chairs
Chairs (office)
Chair stock
China closets
Church pews
Clocks
Clothes props
Corn shellers
Cornices
Crating
Cultivator handles
Decking
Disc harrow parts
Doors
Doubletrees (farm implements)
Drags (farm implements)
Dressers
Dressing tables
Elevator flooring
Eveners (farm implements)

File cases
Fixtures (bank)
Fixtures (barber shop)
Fixtures (display window)
Fixtures (soda fountain)
Flooring (hardwood)
Flag staffs
Folding beds
Folding machines
Frames (couches)
Frames (davenport)
Frames (light and heavy vehicle bodies)
Frames (upholstered parlor furniture)
Furniture
Hallracks
Hay-loader parts
Interior finish
Kitchen cabinets (exterior)
Laundry appliances
Lodge furniture
Mantels
Manure spreaders
Mission furniture
Molding (stairwork)
Organ (pipe) cases
Organ actions
Organs
Parquetry flooring
Patterns
Piano benches
Piano cases
Piano parts
Piano stools
Piano tops
Picture molding
Planing mill products
Platforms (stairwork)
Plow beams
Plow handles
Plow parts (gang)
Plow rounds
Plumbers' woodwork
Pokes (animal)
Porch work
Refrigerators
Rocker frames (upholstered furniture)
Sash
Sheathing
Showcases
Sideboards (built in)
Sideboards (exterior work)
Signs
Sling crossbars
Stirrups
Sulky plow parts
Table legs
Tables (extension)
Tables (library)
Tables (writing)
Tabourets
Tanks (water closets)
Trucks
Toys
Vehicles
Veneer
Wainscoting
Washstands
Woodenware

Oregon oak is used on the Pacific Coast in place of both white and red oak from the East, and especially for baskets, boats (frames, interior, finish, keels, ribs, sills), fixtures, furniture (cabinets, chair stock, table tops), handles, interior work, insulator pins, saddles, and wagons.

The tanbark oak of California is an important source of tanbark in that state. It has not been much used for lumber so far; but, with the methods of cutting and seasoning adapted to a hardwood, it will prove useful for many purposes.

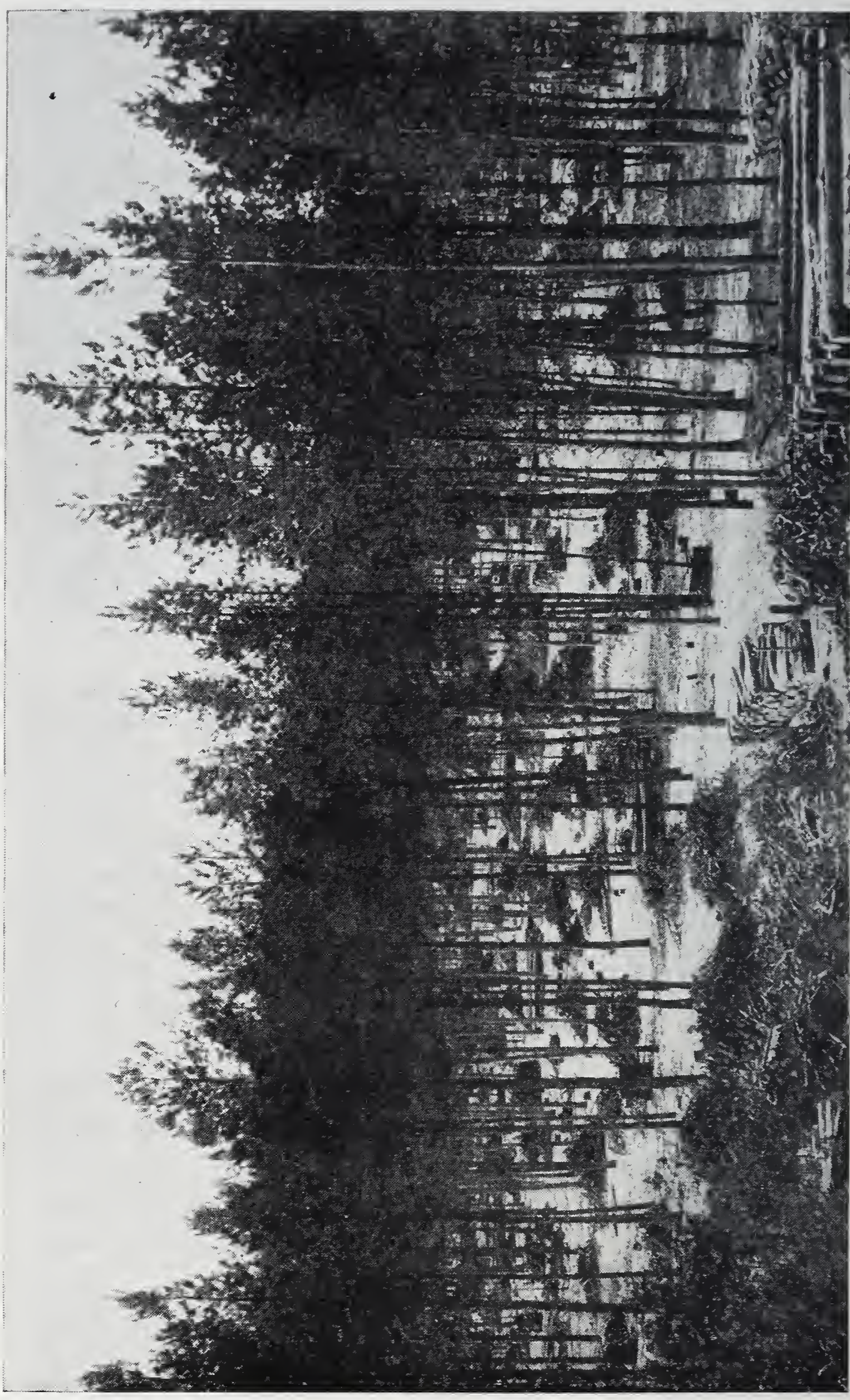

Fig. 86.—Lumbering Operations in Western Yellow Pine in a National Forest. Logs Skidded, Cordwood Ricked, and Brush Piled. Young, Thrifty Trees Left to Produce Another Crop of Timber. A Fine Example of Conservative Harvesting.

OSAGE ORANGE

Osage orange (*Toxylon pomiferum*) is the heaviest, hardest, and toughest American wood so far tested; but in strength and stiffness it is somewhat surpassed by black locust. It is one of the most durable woods, and fence-posts of it give very long service. Because of the poor form of the tree and its rarity in native condition, except in a rather limited region in Oklahoma and Texas, not much osage orange lumber is produced. The largest use is for wagon felloes for service in arid regions. Osage orange is especially adapted to this purpose, because of the very small amount which it shrinks and its great toughness.

Such factory uses as are reported for osage orange are summarized in Table 95.

TABLE 95

FACTORY USES OF OSAGE ORANGE

Purpose	Per Cent
Vehicles	84
Woodenware and Novelties	9
Car Construction	6
Other Uses	1
Total	100

Osage orange is also used to some extent for canes, clock cases, furniture parts, insulator pins, hubs, inlaid work, and mauls.

PERSIMMON

The persimmon (*Diospyros virginiana*) is a member of the ebony family; and its dark heartwood resembles ebony in being very heavy, hard, and strong. Persimmon wood is very fine-grained, takes a high polish, and is extremely resistant to wear. For this reason, persimmon finds its largest use in the manufacture of shuttles, along with dogwood. The process of manufacture for the latter is illustrated on page 274.

Fig. 87.—Redwoods in California.

The reported uses of persimmon are indicated in Table 96.

TABLE 96

FACTORY USES OF PERSIMMON

Purpose	Per Cent
Shuttles	82
Boot and Shoe Findings	11
Sporting and Athletic Goods	6
Other Uses	1
Total	100

PINE

The pines are found to some extent in almost every forest region, and, in total number of species, are as numerous as the oaks. They furnish nearly half of the annual lumber supply.

There are two large groups of pines, as there are two main groups of oaks. These are the white pines and the yellow pines. Aside from the common white pine (*Pinus strobus*), of which more lumber has so far been manufactured than of any other species in the United States, other important members of the white pine family are Western white pine (*Pinus monticola*), which is most abundant in western Montana and northern Idaho; and sugar pine (*Pinus lambertiana*), of the Sierra region of California and southern Oregon.

In the yellow pine group are longleaf pine (*Pinus palustris*), shortleaf pine (*Pinus echinata*), loblolly pine (*Pinus taeda*), and Cuban pine (*Pinus heterophylla*), of the South; pitch pine (*Pinus rigida*), which occurs both north and south in the Eastern States; Norway or red pine (*Pinus resinosa*), of New England and the Lake States; jack pine (*Pinus divaricata*), of the Lake States; lodgepole pine (*Pinus contorta*), of the Rocky Mountain region; and Western yellow pine (*Pinus ponderosa*), from the Black Hills to the Pacific Coast.

There are so many trade names applied to the pines without distinction of species that the reader is often confused. Much of the Southern pine goes to market simply as yellow pine; but the loblolly pine of the North Carolina-Virginia district is called North Carolina pine, while Georgia pine is a time-honored term for the longleaf pine of that State. Arkansas soft pine is a trade

designation for the shortleaf pine of Arkansas. Some of the white pine and Norway pine in the Lake States is sold under the common name of Northern pine. Western yellow pine is marketed under a variety of names; but the most common designation, aside from California white pine, is simply Western pine, the term applied in the Montana-Idaho-Washington region.

TABLE 97

FACTORY USES OF PINE

WHITE PINE

Purpose	Per Cent
Millwork	49
Boxes and Crates	36
Car Construction	2
Matches	2
Rollers, Shade and Map	2
Woodenware, Novelties, etc	1
Caskets and Coffins	1
Other Uses	7
Total	100

SOUTHERN YELLOW PINE

Millwork	75
Boxes and Crates	12
Car Construction	8
Agricultural Implements	1
Other Uses	4
Total	100

SUGAR PINE

Millwork	55
Boxes and Crates	40
Musical Instruments	2
Other Uses	3
Total	100

WESTERN YELLOW PINE

Boxes and Crates	51
Millwork	47
Other Uses	2
Total	100

As will be seen from the comparisons in the chapter on properties of wood, the weight, strength, stiffness, and toughness of the pines are as varied as are the numerous species. The white pines are light in weight, soft, even-grained, and easily worked, being in this respect much like the spruces and cedars. Longleaf pine is the heaviest, hardest, strongest, stiffest, and toughest softwood, and, in these properties, ranks ahead of a number of the hardwoods. Between white pine and longleaf pine, the other pines offer almost every gradation in properties.

All of the pines are largely in demand for general building purposes. In addition to these, the statistical reports furnish the data summarized in Table 97 as to the factory uses of white pine, sugar pine, Western pine, and Southern yellow pine, the latter being made without reference to species.

The varied usefulness of the pines is still further indicated by reports of their consumption in the manufacture of the following articles:

WHITE PINE

Agricultural implements
Actions (organ)
Actions (piano)
Actions (piano players)
Automobile bodies
Balusters (porch)
Barrel-starchers (laundry)
Beehives
Bellows (blacksmith)
Bellows (reed organs)
Blinds
Boat parts (row)
Bookcases (inside)
Bottoms (wagon boxes)
Bottoms (water tanks)
Boxes
Boxes (organ)
Boxes (piano)
Boxes (yeast)
Box shooks
Brackets (cornice)
Brackets (porch)
Brooders (poultry)
Buckets
Cabin parts (boats)
Cabinet work (unexposed)
Capitals
Cases (soft drink bottles)
Cases (milk bottles)
Cases (railroad tickets)
Cases (piano parts)
Caskets
Casting patterns
Chests (organ)
China cases (inside work)
Clocks
Coffins
Columns (porch)
Coops (poultry)
Covers (door panels)
Cores (tin-clad doors)
Cornices
Corn shellers
Couches (box)
Crating
Cupolas (foundry)
Deadwood (tank towers)
Desks (tank towers)

Door frames
Doors
Elevator guide posts
Elevator platforms
Feed mills
Fixtures (barroom)
Fixtures (soda fountain)
Flooring (motor boats)
Foundry flasks
Frames (couches)
Frames (davenports)
Frames (lounges)
Freight cars
Furniture (inside)
Girdles
Grain doors
Grain elevators
Horizontal folding doors
Incubators
Insulation (refrigerator cars)
Interior finish
Keys (piano)
Kitchen cabinets
Ladders
Launch parts
Laundry machines (hydraulic)
Linings (Ry. box cars)
Log-car templates
Matches
Molding
Office fixtures
Pails
Passenger cars
Patterns
Pharmaceutical packing cases
Picture frames
Planking (boats)
Porch columns
Portable farm forges
Pumps
Refrigerators
Saddlery cutting boards
Sash
Shredders
Siding
Silos
Steam-pipe casing
Tanks
Threshers
Tobacco cases
Track levels, railroad
Traction engines
Trunks
Tubs
Washing machines
Water pipes
Weighers
Windmills
Windmill tanks
Window frames
Windstackers
Woodenware

NORWAY PINE

Agricultural implements
Automobile blocking
Baskets
Bed slats
Beehives
Boat decking
Boat keels
Boat planking
Boat sheathing
Boxes
Brackets
Candy buckets
Ceiling
Cornice
Cornshellers
Crates
Derricks
Doors
Dump cars
Extension ladders
Fish kits
Flasks
Flooring
Frames
Freight cars
Furniture

Grass seeders
Hay presses
Interior finish
Kegs for cattle powder
Ladders
Lard buckets
Log cars
Machine decking
Patterns
Piano ribs
Piano players
Porch work
Portable farm forges
Putty kegs
Sash
Sawmill frames
Separators
Shade rollers
Signs
Silos
Swings
Templets
Threshing machines
Wagon beds
Wardrobes
Windmill platforms
Window frames

LONGLEAF PINE

Awning frames
Balusters
Baseboards
Bases (gasoline engines)
Beds (coal wagons)
Binder parts
Boat decking
Bottoms (heavy vehicles)
Bottoms (light vehicles)
Boxboards (dump carts)
Boxboards (wagons)
Boxes
Box shooks
Brackets (cornice)
Brackets (interior trimmings)
Brackets (porch)
Cabinets (dental)
Cabinets (jewelry)
Cabinets (toilet)
Cabinet work
Capitals
Car sills
Cases (china)
Cases (medicine)
Casing
Ceiling
Climbing poles (gymnasium)
Cold storage rooms
Colonnades
Columns (porch)
Consoles
Cores (veneer doors)
Cores (veneer panels)
Corn husker parts
Corn pickers
Cotton pickers
Covers (water tanks)
Cradles (tank cars)
Cranes (flooring)
Crating
Cultivator parts
Decking (freight cars)
Decks (boats)
Derrick beams
Disc harrow parts
Display racks (rugs)
Door frames
Doors
Doors (railway box cars)
Drill boxes (farm implements)
Elevator guide posts
Elevators
Eveners (harrows)
Feed mills
Finish (boats)
Fixtures (laboratory)
Fixtures (office, cafe)
Flag poles
Flasks
Flooring
Flooring (freight cars)
Flooring (railway refrigerator cars)

Flooring (scale platforms)
Frames (box cars)
Frames (motor boat hulls)
Frost boxes (windmills)
Gears (heavy wagons)
Grain elevators
Grille work
Hand cars
Handrails (stairwork)
Hayloader parts
Hay presses
Hayracks
Hayrake parts
Head blocks (tank cars)
Header parts
Hydraulic jacks (parts)
Ice boxes
Interior finish
Ladders (extension)
Ladders (step)
Lawn swings
Linings (box cars)
Linings (incubator bodies)
Mantels
Moldings (interior finish)
Neck yokes
Needle beams (railway car frames)
Newels (stairwork)
Ornaments (furniture)
Panels (veneered)
Passenger cars (frames)
Pianos (interior work)
Pickets (fence)
Picture moldings
Platforms (tank towers)
Plow parts (gang)
Poles (farm implements)
Poles (wagons)
Posts (stairwork)
Pump rods (windmills)
Railway motor car parts
Railway push cars
Refrigerators
Risers (stairwork)
Road machinery
Road tools
Roofing (box cars)
Screen doors
Seats (water closets)
Seed-corn driers
Seeder boxes (farm implements)
Shoveling boards (farm wagons)
Sideboards (built in)
Side plates (railway freight cars)
Siding (box cars)
Signboards
Signs (advertising)
Sills (railway cars)
Silos
Skids (engine)
Slats (railway cattle cars)
Stacker parts (farm machinery)
Steps (stairwork)
Stringers (railway cars)
Sulky plow parts
Sweeps (feed mills)
Sweeps (water tanks)
Tackle blocks
Tanks (acid)
Tent poles
Threshing machines
Tobacco cases
Tongues (binders)
Tongues (cotton planters)
Tongues (manure spreaders)
Tongues (plows and cultivators)
Tongues (wagons)
Wagon dumps
Wainscoting
Washing machines (hand)
Washing machines (hydraulic)
Well-digging machines
Window frames
Windmills

LOBLOLLY PINE

Agricultural implements
Balusters
Baseboards
Basket bottoms
Blinds
Boat construction

Boxes
Boxes (coffee)
Boxes (dry goods)
Box shooks
Cabbage crates
Cabinets
Car decking
Car siding
Casing
Ceiling
Clapboards
Coffins
Conduits
Cornices
Crating
Cross-arms
Decking (freight cars)
Doors
Door frames
Dunnage (freight cars)
Excelsior
Fixtures
Furniture backs
Furniture (veneer cores)
Flooring
Flooring (factory)
Flooring (freight car)
Grain doors
Interior trim (house)
Kitchen cabinets
Ladders
Landing posts
Lining (freight cars)
Moldings
Newel posts
Outer cases (casket)
Panels (furniture sides)
Partition
Pilasters
Poultry coop (bottoms)
Refrigerators
Roofers
Sample cases
Sash
Screens (door)
Screens (window)
Siding
Siding (freight cars)
Silos
Stair rails
Stairways
Store fronts
Tanks
Trunk boxes
Vehicles
Wagon panels
Wardrobes
Window frames
Wire reels
Woodenware

Western white pine, sugar pine, and much of the Western yellow pine are used for the same general purposes as Eastern white pine. The first two are true white pines, while the sapwood of the Western yellow pine resembles white pine in several respects.

The uses of shortleaf pine are as numerous and diversified as those listed for longleaf and loblolly pine.

YELLOW POPLAR

Yellow poplar (*Liriodendron tulipifera*) is a light, soft, fine-grained, easily worked durable wood in many respects much like basswood. It has a wide range of usefulness; and, in addition

to serving in its own proper form, yellow poplar is also much used as a backing for veneer of other woods.

The factory uses most largely reported for yellow poplar are indicated in Table 98.

TABLE 98

FACTORY USES OF YELLOW POPLAR

Purpose	Per Cent
Millwork	35
Boxes and Crates	24
Furniture and Fixtures	10
Vehicles	7
Musical Instruments	6
Car Construction	5
Bungs and Faucets	3
Agricultural Implements	2
Caskets and Coffins	1
Sewing Machines	1
Woodenware and Novelties	1
Tobacco Boxes	1
Other Uses	4
Total	100

The following list of articles in the manufacture of which yellow poplar is used, gives a still better idea of the varied purposes which this wood serves:

Actions (piano players)
Airplanes
Agricultural implements
Automobiles
Backs (washboards)
Barber chairs
Baseboards
Baskets (fruit)
Bevel siding
Billiard tables
Blinds
Bookcases
Bowling alleys
Boxboards (heavy vehicles)
Boxes (veneer)
Box shooks
Brush blocks
Carvings
Cabinets
Car repairing
Car construction
Carpet sweepers
Cart beds
Cases (medicine)
Casing
Caskets
Ceiling
Church furniture
China closets (inside)
Cider mills
Cigar boxes
Churns
Coffins
Cornice
Corn shellers
Costumers
Crates (fruit and vegetable)
Crating
Desks (inside)
Drawer bottoms (furniture)

Doors
Egg cases
Elevators
Elevators (corn)
Evaporator pan sides
Exterior finish
Facia
Feedcutter tables
Fixtures (bank)
Fixtures (bar)
Fixtures (display windows)
Fixtures (laboratory)
Fixtures (store and office)
Flooring
Flour mills (machinery parts)
Frames (couches)
Frames (davenports)
Frames (lounges)
Frames (organ interior)
Frames (upholstered furniture)
Furniture (inside)
Goldleaf work
Guitar bodies
Guitar necks
Handles
Header parts
Hoppers
Interior finish
Ironing-boards
Keels (boats)
Ladders
Laundry machines (hand)
Laundry machines (hydraulic)
Lawn swings
Lodge furniture
Mandolin bodies
Mandolin necks
Matches
Moldings (piano cases)
Music cabinets (inside work)
Organ parts (interior)
Organ pipes
Packages (fruit and vegetable)
Panels (automobile bodies)
Panels (vehicle bodies)
Panels (veneered)
Passenger cars (interior work)
Patterns
Pedestals
Peels (bakers')
Piano parts
Picture moldings
Pipe organs (interior parts)
Pool tables
Porch columns
Pulpits (church)
Pumps
Railway motor car parts
Refrigerators
Rollers (farm machinery)
Sash
Screen doors
Seats (automobile)
Seats (buggy)
Seats (carriages)
Seats (water closets)
Seeder boxes (farm implements)
Separator sides (threshers)
Sewing machine parts
Sideboards (built in)
Siding (grain grinders)
Siding (refrigerator cars)
Siding (wagon beds)
Somnols
Stacker parts (farm machinery)
Tables (café)
Tables (dining)
Tables (kitchen)
Telephones
Threshing machines
Troughs (bakers')
Trunks
Type cabinets
Vane slats (windmill)
Veneer cores (organ cases)
Veneer cores (piano)
Wardrobes (inside)
Washing machines (laundry)
Well machinery
Wheels slats (windmill)
Window screens
Woodenware
Zither bodies

REDWOOD

Redwood (*Sequoia sempervirens*) is a very soft, light, straight-grained softwood of great size and durability. Redwood ranks among the stronger woods in proportion to its weight. While in cross-breaking strength it is surpassed by a number of the stronger softwoods, redwood ranks close to longleaf pine in resistance to end-crushing.

Redwood finds its largest use in general building, and especially for siding and shingles, where its great durability is especially desirable. Redwood is much used for millwork because of its comparative freedom from swelling and shrinking with atmospheric changes, after it is once thoroughly seasoned.

The more important factory uses reported for redwood are as indicated in Table 99.

TABLE 99

Factory Uses of Redwood

Purpose	Per Cent
Millwork	78
Pumps and Wood Pipe	7
Tanks and Silos	7
Woodenware and Novelties	3
Boxes and Crates	2
Caskets and Coffins	1
Furniture and Fixtures	1
Other Uses	1
Total	100

Other common uses for redwood are for:

Boat finish
Caskets
Cabinets
Coffins
Dairymen's supplies
Doors
Flasks
Fixtures
Incubators
Interior finish
Molding
Musical instruments
Patterns
Porch columns
Sash
Signs
Silos
Tanks
Windmills

SASSAFRAS

Sassafras (*Sassafras sassafras*) is a soft hardwood of medium weight and much durability. The supply of sassafras lumber is not large, but it serves good purposes where available. Nearly all of it goes into various forms of millwork, and a small proportion into furniture and fixtures.

The reports indicate that sassafras is also used to some extent in the manufacture of novelties, souvenirs, and woodenware.

SPRUCE

Like the term cedar, the word spruce covers a number of species both Eastern and Western. Important from the wood-using standpoint are the red spruce (*Picea rubens*), which is abundant in New England, and extends southward on the mountain ranges as far as North Carolina; black spruce (*Picea mariana*), which occurs in the northern part of the range of the red spruce and in the Lake States; and white spruce (*Picea canadensis*), which is the principal spruce of the Lake States. These species are the largest source of wood for paper pulp, and also furnish all the spruce lumber manufactured in the East. In the Rocky Mountain region, the spruce which is most manufactured into lumber is Engelmann spruce (*Picea engelmanni*); while, in the Pacific Northwest, Sitka spruce (*Picea sitchensis*) is the chief source of spruce lumber. Of all these species, red spruce and Sitka spruce are by far the most abundant and important.

The wood of the spruces is very light in weight, soft, even-grained, and easily worked, even exceeding white pine in this respect. Spruce is stiff and strong in proportion to its weight. One of the most exacting demands among the industries is that of wood for piano sounding boards; and for this purpose spruce has long been the chief supply. Recently spruce has found a new use in the manufacture of airplanes.

The factory uses reported for spruce without distinction of species are indicated in Table 100.

TABLE 100

FACTORY USES OF SPRUCE

Purpose	Per Cent
Millwork	45
Boxes and Crates	42
Musical Instruments	4
Woodenware, Novelties, etc.	4
Tanks and Silos	1
Other Uses	4
Total	100

Eastern spruce is credited in the reports with being used in the manufacture of:

Agricultural implements
Airplanes
Boats
Boat oars
Bowling alleys
Boxes
Broom handles
Bungs
Butter tubs
Cable reels and spools
Cameras
Canoes
Car sheathing
Crates
Doors
Elevator platforms
Farm machinery
Fiber board
Fixtures, backing
Fixtures, linings
Fixtures, office
Fixtures, store
Flag poles
Flooring
Furniture (hidden parts)
Guitars
Hay presses
Ice boxes
Interior finish
Keyboards
Ladder sides
Mandolins
Match cases
Moldings
Molding flasks
Musical instruments
Novelties
Organ pipes
Paddles
Patterns
Piano backs
Piano benches
Piano cases
Piano ribs
Piano sounding-boards
Pipe organs
Player actions
Refrigerators (inside partitions)
Scaffolding
Ships
Shiplap
Silos
Skids
Sleds
Spars
Tables (ironing)
Tables (folding)
Tanks
Tubs
Vehicles
Woodenware

Specific uses reported for hackberry include:

Buggy bodies	Rakes
Cart trees	Saddle trees
Farm implements	Stair rails
Handles	Steps
Furniture	Table legs and tops
Hoe handles	Tubs
Interior finish	Wagon parts
Kegs	

Louisiana factories use sugarberry for:

Car finish	Stair steps
Furniture	Table frames
Railing	Tool handles
Slack cooperage	Vehicle bodies

HEMLOCK

Commercially, there are two important species of hemlock —the Eastern hemlock (*Tsuga canadensis*), which is most abundant in the Lake States, West Virginia, Pennsylvania, New York, and New England; and Western hemlock (*Tsuga heterophylla*), the largest stands of which are in the Pacific Northwest.

The Eastern hemlock is among the lighter woods in weight, fairly stiff and strong, and tougher than most softwoods. The Western hemlock is heavier, stronger, and stiffer than the Eastern, and, in mechanical properties, rather closely approaches Douglas fir. A large proportion of the hemlock lumber goes directly from the sawmill into general building operations.

Without distinction between species, the reports indicate the factory uses of hemlock as given in Table 86.

TABLE 86

FACTORY USES OF HEMLOCK

Purpose	Per Cent
Millwork	62
Boxes and Crates	29
Car Construction	2
Furniture	1
Trunks and Valises	1
Refrigerators and Kitchen Cabinets	1
Other Uses	4
Total	100

More specifically, Eastern hemlock enters into the manufacture of the following articles:

Bakers' machinery
Beamboxes (weighing machines)
Boat parts
Boxes
Car decking
Car doors
Crating
Flasks
Flooring
Ice boxes
Interior finish
Pails
Piano boxes
Portable farm forges
Refrigerators
Sash
Seed boxes (machines)
Shop patterns (boats)
Siding
Signs
Silos
Tobacco cases
Trunks
Tubs
Vehicles
Washboards
Well machine parts
Window frames

According to the Oregon and Washington reports, Western hemlock is used on the Pacific Coast for:

Boat finish
Boxes
Caskets
Cooperage
Crates
Fixtures (drawers, shelves)
Furniture (backing, couches, kitchen table tops)
Interior work (casing, ceiling, finish, flooring, molding, wainscoting)
Pulp
Sash and doors
Screens and veneer

HICKORY

There are a number of species of hickory; but those of greatest commercial importance are five, as follows: Shellbark (*Hicoria laciniosa*), shagbark (*Hicoria ovata*), mockernut (*Hicoria alba*), bitternut (*Hicoria minima*), and pignut (*Hicoria glabra*). The pecan (*Hicoria pecan*) is also a hickory, and is used to some extent for the same purposes as the other species.

The hickories, with the exception of black locust and osage orange, are the heaviest, strongest, and toughest of our native woods. It is the remarkable toughness of hickory, and its ability to withstand shocks, that make it the wood above all others for vehicle work.

All the hickories are used in the manufacture of vehicles, handles, and other articles where strength and toughness are the main consideration; but pignut perhaps possesses these properties in greater degree than any of the other species.

The factory uses of hickory are indicated in Table 87.

TABLE 87

Factory Uses of Hickory

Purpose	Per Cent
Vehicles	61
Handles	31
Agricultural Implements	3
Sporting and Athletic Goods	1
Other Uses	4
Total	100

A great deal of hickory, instead of being manufactured into lumber, goes in bolt form directly to the factory in which it is to be fashioned into some useful article. According to the reports, hickory enters more or less into the construction of:

Agricultural implements
Axles (light vehicles)
Baskets
Baseball bats
Binder parts
Board rules
Bottoms (wagon boxes)
Brake bars
Cabinet work
Calking hammers
Canes
Car repairing
Car construction
Carvings
Chairs
Corn binder parts
Crossbars (light vehicles)
Crutches
Cultivator handles
Doubletrees
Dowels
Eveners (farm implements)
Felloes
Freight cars
Gear woods (light vehicles)
Golf sticks (handles)
Hammer handles
Handles
Handles (broom)
Handles (edge tools)
Hay baler parts
Hay loader parts
Header parts
Hounds (heavy vehicles)
Ladders
Ladder rungs
Log rules
Machinery handles
Mallets
Manure spreader parts
Maul handles
Molds (brick)
Neck yokes (implement)
Neck yokes (plows)

Neck yokes (vehicles)
Patterns
Pike poles
Pins
Picture molding
Picker sticks
Pick handles
Pitmans (farm implements)
Plow beams
Plow handles
Poles (light vehicle)
Rake teeth
Refrigerators
Revolving rakes
Rims (automobile wheels)
Rims (vehicle wheels)
Road-scrapers
Shafts (vehicle)
Singletrees
Sledge handles
Small tool handles
Spokes (automobile)
Spokes (light and heavy vehicles)
Spring bars (light vehicles)
Sucker rods
Threshing machines
Tongues (light vehicles)
Tongues (wagon)
Tongues (wheel scrapers)
Trapeze (gymnasium)
Trucks
Trunk slats
Turnings
Wagon stock
Wagon jacks
Whiffletrees
Windmill rods

HOLLY

Holly (*Ilex opaca*) is a tough, close-grained wood of ivory-like appearance, which makes it especially valuable for inlay work and in the manufacture of many small articles. Since holly trees are neither large nor abundant, only small quantities of this wood are available. The factory uses reported are indicated in Table 88.

TABLE 88

FACTORY USES OF HOLLY

Purpose	Per Cent
Woodenware and Novelties	69
Brushes	24
Musical Instruments	4
Other Uses	3
Total	100

HORNBEAM

Hornbeam or ironwood (*Ostrya virginiana*) is one of the heaviest, hardest, and toughest American woods, ranking very closely to the hickories in these respects. It is not available in such large quantities as the hickories, but is used for much the same purposes, as Table 89 indicates.

Specific uses for hornbeam includes axles, felloes, tongues, levers, canes, umbrella sticks, and whipstocks.

TABLE 89

Factory Uses of Hornbeam

Purpose	Per Cent
Handles	68
Vehicles	21
Millwork	3
Furniture	2
Woodenware and Novelties	2
Other Uses	4
Total	100

LARCH

See Tamarack (page 308).

LAUREL

Laurel (*Kalmia latifolia*) is a fine-grained hardwood, produced in small quantities in the Southern mountains. It is nearly as hard as dogwood, and as heavy as white oak. It is not available in large sizes nor in great quantity, and is known as kalmia in the manufacture of tobacco pipes.

The California laurel (*Umbellularia californica*), or myrtle, is not very abundant, but is used on the Pacific Coast in boat building and for the manufacture of interior finish, fixtures, furniture, pilot wheels, turnery, and novelties as shown in Table 90.

TABLE 90

Factory Uses of Laurel

Purpose	Per Cent
Ship and Boat Building	66
Furniture and Fixtures	19
Brooms and Carpet-Sweepers	7
Woodenware and Novelties	6
Millwork	2
Total	100

LOCUST

There are two native locusts found in the Eastern states—the honey locust (*Gleditsia triacanthos*) and the black locust (*Robinia pseudacacia*). The honey locust is not abundant, however; and so, while possessing many desirable qualities in the way of strength and hardness, is little used.

Black locust and osage orange closely compete for the honor of being the heaviest and strongest American woods. In other respects they split even, for osage orange is the tougher, and black locust the stiffer. Both shrink less in seasoning than almost any other wood, either hard or soft—which is also an extremely desirable quality.

Black locust finds by far its largest use in the manufacture of insulator pins and brackets, with a small amount used for millwork, in ship and boat building, and for vehicles. In ship and boat building, black locust is valuable for treenails, for the ancient method of holding two pieces of wood together by means of a wooden pin or nail has, for some purposes, not been improved upon.

TABLE 91

FACTORY USES OF LOCUST

Purpose	Per Cent
Insulator Pins and Brackets	90
Millwork	3
Ship and Boat Building	3
Vehicles	2
Other Uses	2
Total	100

Black locust is also used for patterns, chucks, hubs, turnery, trunnels, and spokes for boat wheels.

Some of the small amount of honey locust manufactured is used in furniture; millwork, balusters, newels, and molding.

MAGNOLIA

Two species of magnolia are cut for lumber to some extent in the Southern states, in addition to the cucumber tree previously mentioned. These are the evergreen magnolia (*Magnolia*

foetida) and the sweet magnolia (*Magnolia glauca*) or bay tree. Most of the magnolia lumber, however, is made from the evergreen magnolia.

Magnolia wood is of compact structure, light, soft, easily worked, with a satiny luster, and creamy white to light brown in color. It goes to market with yellow poplar, as well as under its proper name. Such separate factory uses of magnolia as are reported are shown in Table 92.

TABLE 92

FACTORY USES OF MAGNOLIA

Purpose	Per Cent
Boxes and Crates	88
Furniture and Fixtures	8
Millwork	2
Tobacco Boxes	1
Other Uses	1
Total	100

More specific uses reported for magnolia include:

Bed-room suites
Boats
Boxes
Broom handles
Brushes
Cabinets
Car sheathing
Cotton gins
China closets
Door panels
Dressers
Egg cases
Excelsior
Furniture
Interior finish
Molding
Ox yokes
Sash
Tables
Wagon boxes
Wash stands

MAPLE

Four species of maple are of commercial importance from the lumber standpoint. These are hard or sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), soft or silver maple (*Acer saccharinum*), and Oregon maple (*Acer macrophyllum*). Hard maple is by far the most abundant and useful member of the group.

The wood of hard maple is of moderate weight for a hardwood, strong, hard, and with good wearing qualities. Variations

in structure and appearance due to peculiarities of growth give curly and bird's-eye effects which are much prized. The wood of soft maple is considerably lighter in weight, and not so strong or stiff as that of the hard maple. It has a good figure, and is used for many purposes. Red maple is about midway between hard and soft maple in weight and strength. In hardness, it is close to the soft maple; and in stiffness, not very far from the hard maple. Oregon maple is the only commercial maple on the Pacific Coast, and is the most important hardwood of that region. The wood resembles that of the Eastern maples, and is used for the same general purposes.

Hard maple is the maple used in the manufacture of hardwood flooring and wherever strength and resistance to wear are the determining qualities.

In the wood-using industry reports, all the maples are grouped together with results shown in Table 93.

TABLE 93

FACTORY USES OF MAPLE

Purpose	Per Cent
Millwork	34
Furniture and Fixtures	17
Boxes and Crates	10
Boot and Shoe Findings	6
Agricultural Implements	5
Musical Instruments	5
Handles	4
Woodenware, Novelties, etc.	4
Vehicles	4
Laundry Appliances	2
Other Uses	9
Total	100

These specific uses reported for hard maple indicate the great serviceability of this wood:

Automobile benches
Automobile bottoms
Automobile gears
Automobile sub-floors
Axles
Baggers
Baseball bats
Baskets
Bean pickers
Bicycle rims
Billiard cues
Billiard rings

Blueprint frames
Bobbins
Bobsleds
Bolsters
Bowling alleys
Bowls
Boxes
Bread boards
Brewers' chips
Broom handles
Brush backs
Brush handles
Built-up panels
Butcher blocks
Butter boxes
Butter ladles
Butter molds
Cameras
Canes
Cant-hook handles
Car-gallows frames
Carpet-sweepers
Carrom cues
Carrom rings
Caster rollers
Cattle guards
Center wheels
Chair bottoms
Chair rods
Checkers
Churn dashers
Clothespins
Coat hangers
Coil bases (telephone)
Corn huskers
Corn planters
Corn shellers
Costumers
Cot frames
Cranes
Croquet balls
Croquet mallets
Culm pipe (mines)
Cultivator handles
Curtain poles
Dashboards
Die blocks
Die cases
Dishes
Dominoes
Door knobs
Dowels
Drawer bottoms
Dumb-bells
Electrotype blocks
Ensilage cutters
Extension stretchers
Factory trucks
Faucets
Feed cutters
Feeders
Flooring
Furniture
Games
Gas-engine skids
Girts
Go-carts
Grain doors
Grain separators
Grills
Guitars
Hand cars
Handles
Handspikes
Hay balers
Hay pressers
Hoop drums
Horizontal bars
Hose menders
Indian clubs
Interior finish
Kitchen cabinets
Knobs (furniture)
Kraut cutters
Ladders
Lasts
Lemon squeezers
Levers
Log cars
Mallets
Mandolins
Mangle rollers
Manual training supplies
Manure spreaders

Meat boards
Medicine cabinets
Mission furniture
Office fixtures
Packing-house cutting tables
Paddles
Pails
Paper cutters
Parasol handles
Parquetry floors
Patterns
Peavy handles
Pianos
Piano bridges
Piano pin planks
Piano players
Plow beams
Plugs
Plumbers' woodwork
Porch swings
Portable sawmills
Potato mashers
Potato planters
Pulley spokes
Pumps
Push cars
Racks
Railroad velocipedes
Reed furniture (rods)
Refrigerators
Riddles
Road rollers
Roller pins
Rules
Sawmill machinery
Scythe snaths
Self feeders
Separators (grain)
Sheeting
Showcases
Shredders
Skewers
Sleighs
Spindles
Spoke wedges
Spool barrels
Spoons
Steak mauls
Steering wheels
Stonecutters' mallets
Stone boats
Store fixtures
Switch boards
Table rims
Talking machines
Tanks
Tanning drums
Tenpins
Threshing machines
Thresholds
Tie plugs
Timber grapples
Tinners mallets
Tin-plate boxes
Toothpicks
Towel racks
Toys
Track gauges
Track levels
Trucks
Trunks
Tubs
Type cabinets
Type cases
Umbrella racks
Wall cases
Wall clocks
Washboards
Washing machines
Weighing machines
Wheelbarrows
Wind stackers
Wooden bearings
Wood knobs (grilles)
Woodtype
Yardsticks

Soft maple is used in the manufacture of:

Auto frames
Baby carriages
Ballot boxes
Berry baskets

Boats
Bookcases
Boxes
Brooders (poultry)
Broom handles
Butter bowls
Carpet sweepers
Chairs
Coat hangers
Corn planters
Cot frames
Cradles
Cultivators (garden)
Door frames
Egg cases
Extension-table sides
Fanning mills
Filing cabinets
Fixtures
Flooring
Furniture
Grass seeders
Hall clocks
Hay racks
Hand sleds
Ice boxes
Incubators
Interior finish
Ironing boards
Kitchen cabinets
Knobs (furniture)
Lap boards
Lawn swings
Manual training supplies
Music cabinets
Office fixtures
Parquet floors
Pianos
Piano benches
Pumps
Potato planters
Reels (wire)
Refrigerators
Root cutters
Signs
Sleeve boards
Table tops
Tabourettes
Tin-plate boxes
Umbrella racks
Vehicles
Velocipedes, railroad
Wardrobes
Woodenware

Oregon maple is used on the West Coast for:

Baskets
Boat finish
Building rollers
Dollies
Fixtures (counter tops, grill work, mirrow frames, show cases)
Furniture (bookcases, chairs, davenport frames, school furniture, spindles, tables)
Handles
Interior work (finish, flooring)
Pulleys
Saddles
Tent toggles
Trunk slats

OAK

Botanists recognize some fifty species of oak in the United States, all but a few of which attain tree size, while many are among the largest and finest hardwoods. With such a wealth of species, it is impossible to get statistics upon the consumption of the separate kinds with any degree of accuracy. Moreover,

most of the oak is marketed under the general names of white oak or red oak, without further specific distinction.

Of the white oak group, the most important are the true white oak (*Quercus alba*), bur oak (*Quercus macrocarpa*), post oak (*Quercus minor*), cow oak (*Quercus michauxii*), chestnut oak (*Quercus prinus*), chinquapin oak (*Quercus acuminata*), overcup oak (*Quercus lyrata*), and Oregon oak (*Quercus garryana*). Of the red oak group, the most useful species are the true red oak (*Quercus borealis*), Texan oak (*Quercus Texana*), yellow oak (*Quercus velutina*), scarlet oak (*Quercus coccinea*), turkey oak (*Quercus catesbaei*), Spanish oak (*Quercus digitata*), pin oak (*Quercus palustris*), shingle oak (*Quercus imbricaria*), and willow oak (*Quercus phellos*). The white and red oak groups supply about equal amounts of lumber. Two other important species which belong to neither group are live oak (*Quercus virginiana*) and California tanbark oak (*Quercus densiflora*).

The wood of nearly all the oaks is heavy, hard, strong, and tough, with the characteristic figure which has always made oak a standard cabinet, furniture, finish, and flooring wood, in addition to its great usefulness for vehicles and in other places where strength is essential.

There is, of course, considerable variation in the strength, hardness, stiffness, weight, and other properties of the oaks, as is shown in the chapter upon the properties of wood. Among all the oaks, the live oak leads in strength, hardness, and toughness. In the days of wooden ships, it was especially in demand. The supply of live oak timber is much less than that of many other oaks; and at present but little is manufactured into lumber.

Without regard to species, the factory uses of oak are summarized in Table 94.

TABLE 94

FACTORY USES OF OAK

Purpose	Per Cent
Furniture and Fixtures	32
Millwork	25
Car Construction	15
Vehicles	11
Agricultural Implements	3
Boxes and Crates	3
Ship and Boat Building	2
Refrigerators and Kitchen Cabinets	2
Musical Instruments	1
Sewing Machines	1
Other Uses	5
Total	100

The many specific uses for white oak are illustrated by the following list of articles in which this wood is used in the factories of Illinois:

Altars (church)
Art lamps
Axe handles
Backgrounds (display windows)
Ball racks (pool and billiard)
Balusters
Barber chairs
Barber furniture
Bar fixtures
Bars (wooden harrows)
Baseboards
Basket parts
Beams (plow)
Beds
Beds (cot)
Beds (folding)
Billiard (tables)
Binder parts
Boat parts (row)
Bobsleds
Bolsters (heavy vehicles)
Bookcases
Book racks
Bottoms (baggage trucks)
Bottoms (delivery wagons)
Braces (railway car frames)
Brackets
Brake beams (heavy vehicles)
Brush blocks
Buffets (exterior)
Bumping posts (railroad)
Butter churn bodies
Butter churn bottoms
Cabinets (dental)
Cabinets (filing)
Cabinets (music rolls)
Cabinets (parlor)
Cabinets (phonograph records)
Cabinets (toilet)
Cabinets (towels)
Cabins (boats)
Capitals
Card tables
Cases (medicine)
Cases (railroad ticket)
Casing
Caskets
Chair frames

Chairs
Chairs (adjustable)
Chairs (invalid)
Chairs (office)
Chairs, official (lodge room)
Chairs (rolling)
Chairs (stenographers)
Cheval mirrors
Chiffoniers
China closets
Church pews
Cigar wheels (wheel-of-chance)
Clay gatherers (machine parts)
Cleats (wagon boxes)
Coffins
Colonnades
Columns (porch)
Consoles
Cores (veneer doors)
Corn binders
Corn grinders
Costumers
Couches (folding)
Counters (bar)
Counters (store)
Cradles
Cue racks (pool and billiard)
Cultivator handles
Desks (electric switchboards)
Desks (house)
Desks (office)
Disc drill parts
Disc harrow parts
Door frames (box cars)
Doors
Doubletrees (farm implements)
Doubletrees (vehicle)
Drags (farm implements)
Dressers
Dressing tables
Drill parts (farm implements)
Drum lagging (hoisting engine)
Edge-tool handles
Electric cars (interior finish)
Elevator cages
Eveners (farm implements)
Felloes
File cases
Finish (boats)
Fixtures (bank)
Fixtures (barbershop)
Fixtures (display window)
Fixtures (laboratory)
Fixtures (soda fountain)
Fixtures (store and office)
Flooring (hardwood)
Folding beds
Folding screens
Frames (couches)
Frames (davenports)
Frames (dummy carts)
Frames (electric cars)
Frames (freight cars)
Frames (light vehicle bodies)
Frames (lounges)
Frames (motor boats)
Frames (upholstered furniture)
Frames (vessels)
Frames (windows)
Furniture
Gear woods (light vehicle)
Grilles
Guitar bodies
Hall racks
Hammer handles
Handles
Hand rails (stairwork)
Harrows
Hatracks
Hay baler parts
Hayrake parts
Horse powers
Hounds
Hubs (heavy vehicle wheel)
Hulls (boats)
Hydraulic jacks
Interior finish
Keels (boats)
Keels (motor boats)
Keyracks
Kitchen cabinets (exterior)
Kitchen cupboards
Kitchen safes
Ladders (gymnasium)

Launch parts
Lawn swings
Leaves (table)
Legs (piano)
Library cases
Lodge furniture
Machine handles
Mandolin bodies
Mantels
Manure spreaders
Merry-go-round parts
Mirror cases
Mission furniture
Molding (house trimming)
Molding (piano)
Molding (stairwork)
Mug cases (barbershop)
Music cabinets
Necktie racks
Newels
Oil well machine frames
Organ cases
Ornaments (furniture)
Outer cases (caskets)
Panels (veneered)
Paper racks
Parallel bars
Parlor cabinets (exterior)
Parlor rockers
Parquetry flooring
Passenger cars (frames)
Passenger cars (interior finish)
Pedestals
Pedestals (tables)
Pew racks
Piano benches
Piano cases
Piano chairs
Piano players (exterior)
Piano stools
Pick handles
Picture moldings
Pilasters (piano)
Plate racks
Plow beams
Plow handles
Plow rounds
Plow parts (gang)
Plows
Poles (light vehicles)
Pool tables
Posts (railway car frames)
Posts (stairwork)
Pulpits (church)
Racks (hat and coat)
Reaches (heavy vehicles)
Reels (electric light wire)
Refrigerators
Revolving chairs (office)
Revolving chairs (parlor cars)
Rims (heavy vehicle wheels)
Risers (stairwork)
Road-scrapers
Rocker frames (upholstered furniture)
Sand boards
Sash
Screen doors
Seats (water closets)
Sections (wheel-scrapers)
Seeder parts (farm implements)
Serving tables
Sewing tables
Shanks (cultivators)
Shells (drum)
Sideboards (built in)
Sideboards (exterior)
Siding (boats)
Sills (threshers)
Singletrees (cultivators)
Singletrees (vehicle)
Sleds (toy)
Sofa frames (upholstered furniture)
Somnols
Spokes (heavy vehicles)
Spring bars
Spring blocks (Ry. tank cars)
Stacker parts (farm machinery)
Stands
Stands (jardinieres)
Stands (lamps)
Staves (water tanks)
Steps (stairwork)
Stringers (railway cars)

Subscriber sets (telephone)
Sulky plow parts
Sweeps (farm machinery)
Sweeps (windmills)
Switchboards (telephone and telegraph)
Tables (café)
Tables (dining)
Tables (extension)
Tables (library)
Tables (parlor)
Tables (typewriter)
Tables (writing)
Tabourets
Tanks (brewery)
Tanks (distilling)
Tanks (water closets)
Telephones
Threshing machines
Tight cooperage stock
Tongues (wheel-scrapers)
Tool chests
Tool handles
Trays (jewelry)
Type (cabinets)
Typewriter cabinets
Umbrella stands
Vats (distilling)
Vats (oil)
Vending machines (matches)
Vending machines (peanuts)
Vestment cases (church)
Wagon boxes
Wainscoting
Wall cases
Wardrobes (exterior)
Washstands
Water gates
Water wheels
Well-digging machines
Windmill parts
Window screens

The red oaks are used in the manufacture of:

Agricultural implements
Art lamps
Back grounds
Balusters
Barber furniture
Barrow boxes
Baskets
Beds
Bentwood
Billiard tables
Boats
Bob sleds
Bolsters
Bottoms (wagon)
Boxes
Brackets
Brake bars
Bucket staves
Buggy bows
Cabinets
Cabin parts
Car construction
Cars (mine)
Car repairing
Casing (building)
Caskets
Chair frames (upholstered furniture)
Chairs
Chairs (office)
Chair stock
China closets
Church pews
Clocks
Clothes props
Corn shellers
Cornices
Crating
Cultivator handles
Decking
Disc harrow parts
Doors
Doubletrees (farm implements)
Drags (farm implements)
Dressers
Dressing tables
Elevator flooring
Eveners (farm implements)

File cases
Fixtures (bank)
Fixtures (barber shop)
Fixtures (display window)
Fixtures (soda fountain)
Flooring (hardwood)
Flag staffs
Folding beds
Folding machines
Frames (couches)
Frames (davenport)
Frames (light and heavy vehicle bodies)
Frames (upholstered parlor furniture)
Furniture
Hallracks
Hay-loader parts
Interior finish
Kitchen cabinets (exterior)
Laundry appliances
Lodge furniture
Mantels
Manure spreaders
Mission furniture
Molding (stairwork)
Organ (pipe) cases
Organ actions
Organs
Parquetry flooring
Patterns
Piano benches
Piano cases
Piano parts
Piano stools
Piano tops
Picture molding
Planing mill products
Platforms (stairwork)
Plow beams
Plow handles
Plow parts (gang)
Plow rounds
Plumbers' woodwork
Pokes (animal)
Porch work
Refrigerators
Rocker frames (upholstered furniture)
Sash
Sheathing
Showcases
Sideboards (built in)
Sideboards (exterior work)
Signs
Sling crossbars
Stirrups
Sulky plow parts
Table legs
Tables (extension)
Tables (library)
Tables (writing)
Tabourets
Tanks (water closets)
Trucks
Toys
Vehicles
Veneer
Wainscoting
Washstands
Woodenware

Oregon oak is used on the Pacific Coast in place of both white and red oak from the East, and especially for baskets, boats (frames, interior, finish, keels, ribs, sills), fixtures, furniture (cabinets, chair stock, table tops), handles, interior work, insulator pins, saddles, and wagons.

The tanbark oak of California is an important source of tanbark in that state. It has not been much used for lumber so far; but, with the methods of cutting and seasoning adapted to a hardwood, it will prove useful for many purposes.

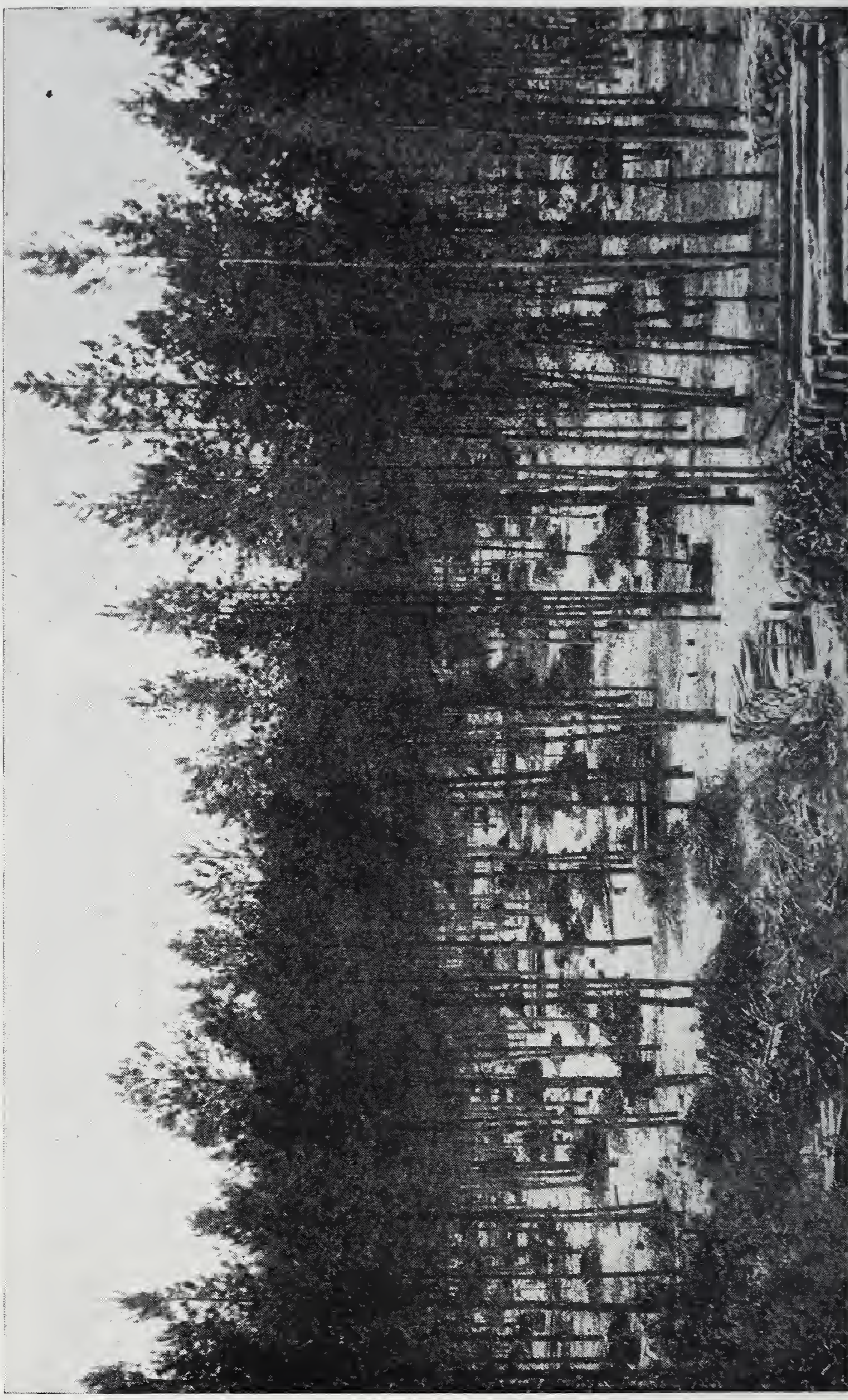

Fig. 86.—Lumbering Operations in Western Yellow Pine in a National Forest. Logs Skidded, Cordwood Ricked, and Brush Piled. Young, Thrifty Trees Left to Produce Another Crop of Timber. A Fine Example of Conservative Harvesting.

OSAGE ORANGE

Osage orange (*Toxylon pomiferum*) is the heaviest, hardest, and toughest American wood so far tested; but in strength and stiffness it is somewhat surpassed by black locust. It is one of the most durable woods, and fence-posts of it give very long service. Because of the poor form of the tree and its rarity in native condition, except in a rather limited region in Oklahoma and Texas, not much osage orange lumber is produced. The largest use is for wagon felloes for service in arid regions. Osage orange is especially adapted to this purpose, because of the very small amount which it shrinks and its great toughness.

Such factory uses as are reported for osage orange are summarized in Table 95.

TABLE 95

FACTORY USES OF OSAGE ORANGE

Purpose	Per Cent
Vehicles	84
Woodenware and Novelties	9
Car Construction	6
Other Uses	1
Total	100

Osage orange is also used to some extent for canes, clock cases, furniture parts, insulator pins, hubs, inlaid work, and mauls.

PERSIMMON

The persimmon (*Diospyros virginiana*) is a member of the ebony family; and its dark heartwood resembles ebony in being very heavy, hard, and strong. Persimmon wood is very fine-grained, takes a high polish, and is extremely resistant to wear. For this reason, persimmon finds its largest use in the manufacture of shuttles, along with dogwood. The process of manufacture for the latter is illustrated on page 274.

Fig. 87.—Redwoods in California.

The reported uses of persimmon are indicated in Table 96.

TABLE 96

FACTORY USES OF PERSIMMON

Purpose	Per Cent
Shuttles	82
Boot and Shoe Findings	11
Sporting and Athletic Goods	6
Other Uses	1
Total	100

PINE

The pines are found to some extent in almost every forest region, and, in total number of species, are as numerous as the oaks. They furnish nearly half of the annual lumber supply.

There are two large groups of pines, as there are two main groups of oaks. These are the white pines and the yellow pines. Aside from the common white pine (*Pinus strobus*), of which more lumber has so far been manufactured than of any other species in the United States, other important members of the white pine family are Western white pine (*Pinus monticola*), which is most abundant in western Montana and northern Idaho; and sugar pine (*Pinus lambertiana*), of the Sierra region of California and southern Oregon.

In the yellow pine group are longleaf pine (*Pinus palustris*), shortleaf pine (*Pinus echinata*), loblolly pine (*Pinus taeda*), and Cuban pine (*Pinus heterophylla*), of the South; pitch pine (*Pinus rigida*), which occurs both north and south in the Eastern States; Norway or red pine (*Pinus resinosa*), of New England and the Lake States; jack pine (*Pinus divaricata*), of the Lake States; lodgepole pine (*Pinus contorta*), of the Rocky Mountain region; and Western yellow pine (*Pinus ponderosa*), from the Black Hills to the Pacific Coast.

There are so many trade names applied to the pines without distinction of species that the reader is often confused. Much of the Southern pine goes to market simply as yellow pine; but the loblolly pine of the North Carolina-Virginia district is called North Carolina pine, while Georgia pine is a time-honored term for the longleaf pine of that State. Arkansas soft pine is a trade

designation for the shortleaf pine of Arkansas. Some of the white pine and Norway pine in the Lake States is sold under the common name of Northern pine. Western yellow pine is marketed under a variety of names; but the most common designation, aside from California white pine, is simply Western pine, the term applied in the Montana-Idaho-Washington region.

TABLE 97

FACTORY USES OF PINE

Purpose	Per Cent
WHITE PINE	
Millwork	49
Boxes and Crates	36
Car Construction	2
Matches	2
Rollers, Shade and Map	2
Woodenware, Novelties, etc	1
Caskets and Coffins	1
Other Uses	7
Total	100
SOUTHERN YELLOW PINE	
Millwork	75
Boxes and Crates	12
Car Construction	8
Agricultural Implements	1
Other Uses	4
Total	100
SUGAR PINE	
Millwork	55
Boxes and Crates	40
Musical Instruments	2
Other Uses	3
Total	100
WESTERN YELLOW PINE	
Boxes and Crates	51
Millwork	47
Other Uses	2
Total	100

As will be seen from the comparisons in the chapter on properties of wood, the weight, strength, stiffness, and toughness of the pines are as varied as are the numerous species. The white pines are light in weight, soft, even-grained, and easily worked, being in this respect much like the spruces and cedars. Longleaf pine is the heaviest, hardest, strongest, stiffest, and toughest softwood, and, in these properties, ranks ahead of a number of the hardwoods. Between white pine and longleaf pine, the other pines offer almost every gradation in properties.

All of the pines are largely in demand for general building purposes. In addition to these, the statistical reports furnish the data summarized in Table 97 as to the factory uses of white pine, sugar pine, Western pine, and Southern yellow pine, the latter being made without reference to species.

The varied usefulness of the pines is still further indicated by reports of their consumption in the manufacture of the following articles:

WHITE PINE

Agricultural implements
Actions (organ)
Actions (piano)
Actions (piano players)
Automobile bodies
Balusters (porch)
Barrel-starchers (laundry)
Beehives
Bellows (blacksmith)
Bellows (reed organs)
Blinds
Boat parts (row)
Bookcases (inside)
Bottoms (wagon boxes)
Bottoms (water tanks)
Boxes
Boxes (organ)
Boxes (piano)
Boxes (yeast)
Box shooks
Brackets (cornice)
Brackets (porch)
Brooders (poultry)
Buckets
Cabin parts (boats)
Cabinet work (unexposed)
Capitals
Cases (soft drink bottles)
Cases (milk bottles)
Cases (railroad tickets)
Cases (piano parts)
Caskets
Casting patterns
Chests (organ)
China cases (inside work)
Clocks
Coffins
Columns (porch)
Coops (poultry)
Covers (door panels)
Cores (tin-clad doors)
Cornices
Corn shellers
Couches (box)
Crating
Cupolas (foundry)
Deadwood (tank towers)
Desks (tank towers)

Door frames
Doors
Elevator guide posts
Elevator platforms
Feed mills
Fixtures (barroom)
Fixtures (soda fountain)
Flooring (motor boats)
Foundry flasks
Frames (couches)
Frames (davenports)
Frames (lounges)
Freight cars
Furniture (inside)
Girdles
Grain doors
Grain elevators
Horizontal folding doors
Incubators
Insulation (refrigerator cars)
Interior finish
Keys (piano)
Kitchen cabinets
Ladders
Launch parts
Laundry machines (hydraulic)
Linings (Ry. box cars)
Log-car templates
Matches
Molding
Office fixtures
Pails
Passenger cars
Patterns
Pharmaceutical packing cases
Picture frames
Planking (boats)
Porch columns
Portable farm forges
Pumps
Refrigerators
Saddlery cutting boards
Sash
Shredders
Siding
Silos
Steam-pipe casing
Tanks
Threshers
Tobacco cases
Track levels, railroad
Traction engines
Trunks
Tubs
Washing machines
Water pipes
Weighers
Windmills
Windmill tanks
Window frames
Windstackers
Woodenware

NORWAY PINE

Agricultural implements
Automobile blocking
Baskets
Bed slats
Beehives
Boat decking
Boat keels
Boat planking
Boat sheathing
Boxes
Brackets
Candy buckets
Ceiling
Cornice
Cornshellers
Crates
Derricks
Doors
Dump cars
Extension ladders
Fish kits
Flasks
Flooring
Frames
Freight cars
Furniture

Grass seeders
Hay presses
Interior finish
Kegs for cattle powder
Ladders
Lard buckets
Log cars
Machine decking
Patterns
Piano ribs
Piano players
Porch work
Portable farm forges
Putty kegs
Sash
Sawmill frames
Separators
Shade rollers
Signs
Silos
Swings
Templets
Threshing machines
Wagon beds
Wardrobes
Windmill platforms
Window frames

LONGLEAF PINE

Awning frames
Balusters
Baseboards
Bases (gasoline engines)
Beds (coal wagons)
Binder parts
Boat decking
Bottoms (heavy vehicles)
Bottoms (light vehicles)
Boxboards (dump carts)
Boxboards (wagons)
Boxes
Box shooks
Brackets (cornice)
Brackets (interior trimmings)
Brackets (porch)
Cabinets (dental)
Cabinets (jewelry)
Cabinets (toilet)
Cabinet work
Capitals
Car sills
Cases (china)
Cases (medicine)
Casing
Ceiling
Climbing poles (gymnasium)
Cold storage rooms
Colonnades
Columns (porch)
Consoles
Cores (veneer doors)
Cores (veneer panels)
Corn husker parts
Corn pickers
Cotton pickers
Covers (water tanks)
Cradles (tank cars)
Cranes (flooring)
Crating
Cultivator parts
Decking (freight cars)
Decks (boats)
Derrick beams
Disc harrow parts
Display racks (rugs)
Door frames
Doors
Doors (railway box cars)
Drill boxes (farm implements)
Elevator guide posts
Elevators
Eveners (harrows)
Feed mills
Finish (boats)
Fixtures (laboratory)
Fixtures (office, cafe)
Flag poles
Flasks
Flooring
Flooring (freight cars)
Flooring (railway refrigerator cars)

Flooring (scale platforms)
Frames (box cars)
Frames (motor boat hulls)
Frost boxes (windmills)
Gears (heavy wagons)
Grain elevators
Grille work
Hand cars
Handrails (stairwork)
Hayloader parts
Hay presses
Hayracks
Hayrake parts
Head blocks (tank cars)
Header parts
Hydraulic jacks (parts)
Ice boxes
Interior finish
Ladders (extension)
Ladders (step)
Lawn swings
Linings (box cars)
Linings (incubator bodies)
Mantels
Moldings (interior finish)
Neck yokes
Needle beams (railway car frames)
Newels (stairwork)
Ornaments (furniture)
Panels (veneered)
Passenger cars (frames)
Pianos (interior work)
Pickets (fence)
Picture moldings
Platforms (tank towers)
Plow parts (gang)
Poles (farm implements)
Poles (wagons)
Posts (stairwork)
Pump rods (windmills)
Railway motor car parts
Railway push cars
Refrigerators
Risers (stairwork)
Road machinery
Road tools
Roofing (box cars)
Screen doors
Seats (water closets)
Seed-corn driers
Seeder boxes (farm implements)
Shoveling boards (farm wagons)
Sideboards (built in)
Side plates (railway freight cars)
Siding (box cars)
Signboards
Signs (advertising)
Sills (railway cars)
Silos
Skids (engine)
Slats (railway cattle cars)
Stacker parts (farm machinery)
Steps (stairwork)
Stringers (railway cars)
Sulky plow parts
Sweeps (feed mills)
Sweeps (water tanks)
Tackle blocks
Tanks (acid)
Tent poles
Threshing machines
Tobacco cases
Tongues (binders)
Tongues (cotton planters)
Tongues (manure spreaders)
Tongues (plows and cultivators)
Tongues (wagons)
Wagon dumps
Wainscoting
Washing machines (hand)
Washing machines (hydraulic)
Well-digging machines
Window frames
Windmills

LOBLOLLY PINE

Agricultural implements
Balusters
Baseboards
Basket bottoms
Blinds
Boat construction

- Boxes
- Boxes (coffee)
- Boxes (dry goods)
- Box shooks
- Cabbage crates
- Cabinets
- Car decking
- Car siding
- Casing
- Ceiling
- Clapboards
- Coffins
- Conduits
- Cornices
- Crating
- Cross-arms
- Decking (freight cars)
- Doors
- Door frames
- Dunnage (freight cars)
- Excelsior
- Fixtures
- Furniture backs
- Furniture (veneer cores)
- Flooring
- Flooring (factory)
- Flooring (freight car)
- Grain doors
- Interior trim (house)
- Kitchen cabinets
- Ladders
- Landing posts
- Lining (freight cars)
- Moldings
- Newel posts
- Outer cases (casket)
- Panels (furniture sides)
- Partition
- Pilasters
- Poultry coop (bottoms)
- Refrigerators
- Roofers
- Sample cases
- Sash
- Screens (door)
- Screens (window)
- Siding
- Siding (freight cars)
- Silos
- Stair rails
- Stairways
- Store fronts
- Tanks
- Trunk boxes
- Vehicles
- Wagon panels
- Wardrobes
- Window frames
- Wire reels
- Woodenware

Western white pine, sugar pine, and much of the Western yellow pine are used for the same general purposes as Eastern white pine. The first two are true white pines, while the sapwood of the Western yellow pine resembles white pine in several respects.

The uses of shortleaf pine are as numerous and diversified as those listed for longleaf and loblolly pine.

YELLOW POPLAR

Yellow poplar (*Liriodendron tulipifera*) is a light, soft, fine-grained, easily worked durable wood in many respects much like basswood. It has a wide range of usefulness; and, in addition

to serving in its own proper form, yellow poplar is also much used as a backing for veneer of other woods.

The factory uses most largely reported for yellow poplar are indicated in Table 98.

TABLE 98

FACTORY USES OF YELLOW POPLAR

Purpose	Per Cent
Millwork	35
Boxes and Crates	24
Furniture and Fixtures	10
Vehicles	7
Musical Instruments	6
Car Construction	5
Bungs and Faucets	3
Agricultural Implements	2
Caskets and Coffins	1
Sewing Machines	1
Woodenware and Novelties	1
Tobacco Boxes	1
Other Uses	4
Total	100

The following list of articles in the manufacture of which yellow poplar is used, gives a still better idea of the varied purposes which this wood serves:

Actions (piano players)
Airplanes
Agricultural implements
Automobiles
Backs (washboards)
Barber chairs
Baseboards
Baskets (fruit)
Bevel siding
Billiard tables
Blinds
Bookcases
Bowling alleys
Boxboards (heavy vehicles)
Boxes (veneer)
Box shooks
Brush blocks
Carvings
Cabinets
Car repairing
Car construction
Carpet sweepers
Cart beds
Cases (medicine)
Casing
Caskets
Ceiling
Church furniture
China closets (inside)
Cider mills
Cigar boxes
Churns
Coffins
Cornice
Corn shellers
Costumers
Crates (fruit and vegetable)
Crating
Desks (inside)
Drawer bottoms (furniture)

Doors
Egg cases
Elevators
Elevators (corn)
Evaporator pan sides
Exterior finish
Facia
Feedcutter tables
Fixtures (bank)
Fixtures (bar)
Fixtures (display windows)
Fixtures (laboratory)
Fixtures (store and office)
Flooring
Flour mills (machinery parts)
Frames (couches)
Frames (davenports)
Frames (lounges)
Frames (organ interior)
Frames (upholstered furniture)
Furniture (inside)
Goldleaf work
Guitar bodies
Guitar necks
Handles
Header parts
Hoppers
Interior finish
Ironing-boards
Keels (boats)
Ladders
Laundry machines (hand)
Laundry machines (hydraulic)
Lawn swings
Lodge furniture
Mandolin bodies
Mandolin necks
Matches
Moldings (piano cases)
Music cabinets (inside work)
Organ parts (interior)
Organ pipes
Packages (fruit and vegetable)
Panels (automobile bodies)
Panels (vehicle bodies)
Panels (veneered)
Passenger cars (interior work)
Patterns
Pedestals
Peels (bakers')
Piano parts
Picture moldings
Pipe organs (interior parts)
Pool tables
Porch columns
Pulpits (church)
Pumps
Railway motor car parts
Refrigerators
Rollers (farm machinery)
Sash
Screen doors
Seats (automobile)
Seats (buggy)
Seats (carriages)
Seats (water closets)
Seeder boxes (farm implements)
Separator sides (threshers)
Sewing machine parts
Sideboards (built in)
Siding (grain grinders)
Siding (refrigerator cars)
Siding (wagon beds)
Somnols
Stacker parts (farm machinery)
Tables (café)
Tables (dining)
Tables (kitchen)
Telephones
Threshing machines
Troughs (bakers')
Trunks
Type cabinets
Vane slats (windmill)
Veneer cores (organ cases)
Veneer cores (piano)
Wardrobes (inside)
Washing machines (laundry)
Well machinery
Wheels slats (windmill)
Window screens
Woodenware
Zither bodies

REDWOOD

Redwood (*Sequoia sempervirens*) is a very soft, light, straight-grained softwood of great size and durability. Redwood ranks among the stronger woods in proportion to its weight. While in cross-breaking strength it is surpassed by a number of the stronger softwoods, redwood ranks close to longleaf pine in resistance to end-crushing.

Redwood finds its largest use in general building, and especially for siding and shingles, where its great durability is especially desirable. Redwood is much used for millwork because of its comparative freedom from swelling and shrinking with atmospheric changes, after it is once thoroughly seasoned.

The more important factory uses reported for redwood are as indicated in Table 99.

TABLE 99

FACTORY USES OF REDWOOD

Purpose	Per Cent
Millwork	78
Pumps and Wood Pipe	7
Tanks and Silos	7
Woodenware and Novelties	3
Boxes and Crates	2
Caskets and Coffins	1
Furniture and Fixtures	1
Other Uses	1
Total	100

Other common uses for redwood are for:

Boat finish
Caskets
Cabinets
Coffins
Dairymen's supplies
Doors
Flasks
Fixtures
Incubators
Interior finish
Molding
Musical instruments
Patterns
Porch columns
Sash
Signs
Silos
Tanks
Windmills

SASSAFRAS

Sassafras (*Sassafras sassafras*) is a soft hardwood of medium weight and much durability. The supply of sassafras lumber is not large, but it serves good purposes where available. Nearly all of it goes into various forms of millwork, and a small proportion into furniture and fixtures.

The reports indicate that sassafras is also used to some extent in the manufacture of novelties, souvenirs, and woodenware.

SPRUCE

Like the term cedar, the word spruce covers a number of species both Eastern and Western. Important from the wood-using standpoint are the red spruce (*Picea rubens*), which is abundant in New England, and extends southward on the mountain ranges as far as North Carolina; black spruce (*Picea mariana*), which occurs in the northern part of the range of the red spruce and in the Lake States; and white spruce (*Picea canadensis*), which is the principal spruce of the Lake States. These species are the largest source of wood for paper pulp, and also furnish all the spruce lumber manufactured in the East. In the Rocky Mountain region, the spruce which is most manufactured into lumber is Engelmann spruce (*Picea engelmanni*); while, in the Pacific Northwest, Sitka spruce (*Picea sitchensis*) is the chief source of spruce lumber. Of all these species, red spruce and Sitka spruce are by far the most abundant and important.

The wood of the spruces is very light in weight, soft, even-grained, and easily worked, even exceeding white pine in this respect. Spruce is stiff and strong in proportion to its weight. One of the most exacting demands among the industries is that of wood for piano sounding boards; and for this purpose spruce has long been the chief supply. Recently spruce has found a new use in the manufacture of airplanes.

The factory uses reported for spruce without distinction of species are indicated in Table 100.

TABLE 100

FACTORY USES OF SPRUCE

Purpose	Per Cent
Millwork	45
Boxes and Crates	42
Musical Instruments	4
Woodenware, Novelties, etc.	4
Tanks and Silos	1
Other Uses	4
Total	100

Eastern spruce is credited in the reports with being used in the manufacture of:

Agricultural implements
Airplanes
Boats
Boat oars
Bowling alleys
Boxes
Broom handles
Bungs
Butter tubs
Cable reels and spools
Cameras
Canoes
Car sheathing
Crates
Doors
Elevator platforms
Farm machinery
Fiber board
Fixtures, backing
Fixtures, linings
Fixtures, office
Fixtures, store
Flag poles
Flooring
Furniture (hidden parts)
Guitars
Hay presses
Ice boxes
Interior finish
Keyboards
Ladder sides
Mandolins
Match cases
Moldings
Molding flasks
Musical instruments
Novelties
Organ pipes
Paddles
Patterns
Piano backs
Piano benches
Piano cases
Piano ribs
Piano sounding-boards
Pipe organs
Player actions
Refrigerators (inside partitions)
Scaffolding
Ships
Shiplap
Silos
Skids
Sleds
Spars
Tables (ironing)
Tables (folding)
Tanks
Tubs
Vehicles
Woodenware

Sitka spruce is used for:

Airplanes
Apparatus (playground)
Balusters (porch)
Baskets
Blinds
Boxes
Breadboards
Brooders (poultry)
Caskets
Cornice brackets
Decking (boats)
Door frames
Doors
Furniture
Fixtures
Ironing boards
Ladders
Organ parts
Organ pipes
Porchwork
Pulleys
Refrigerator rooms
Refrigerators
Ribs (mandolin)
Ribs (piano)
Rims (guitar)
Sash
Scale parts
Siding (wagon beds)
Sounding-boards
Sounding-boards (guitar)
Spars (boats)
Store fronts
Trunks
Washboards
Wheel slats (windmill)
Windmill parts
Window frames
Woodenware

SYCAMORE

Sycamore (*Platanus occidentalis*) is a tough, strong wood, difficult to split. It has a beautiful figure when quarter-sawed, and would find a much larger use were not the supply so limited.

The chief uses reported for sycamore are indicated in Table 101.

TABLE 101

FACTORY USES OF SYCAMORE

Purpose	Per Cent
Boxes and Crates	64
Furniture and Fixtures	12
Millwork	7
Butchers' Blocks	6
Woodenware and Novelties	2
Refrigerators and Kitchen Cabinets	1
Musical Instruments	1
Agricultural Implements	1
Brooms and Carpet-Sweepers	1
Other Uses	5
Total	100

Sycamore is used to some extent in the manufacture of:

- Barber poles
- Barrels (veneer)
- Basket parts
- Baskets (fruit)
- Baskets (vegetable)
- Beds (folding)
- Boat parts (row)
- Boxes
- Box shooks
- Brush blocks
- Butcher blocks
- Cabinet work
- Cigar boxes
- Cooperage stock
- Crating
- Doors
- Fixtures (office)
- Flooring
- Furniture
- Guitar bodies
- Handles
- Hoppers (fruit and vegetable)
- Horses (merry-go-round)
- Ice boxes
- Interior finish
- Mandolin boxes
- Meat blocks
- Merry-go-round parts
- Packages (fruit and vegetable)
- Panels
- Piano backs
- Picture mouldings
- Refrigerators
- Tobacco boxes
- Trunks
- Vehicle bodies
- Veneer cases (piano)
- Washing machines

TAMARACK

With the exception of longleaf pine, tamarack (*Larix laricina*) is the heaviest and one of the strongest and toughest softwoods. It is rated among the more durable woods, and finds its largest use for general building purposes, and especially for heavy timbers.

Lumber from Eastern tamarack is manufactured chiefly in the Lake States; while the Western tamarack, or larch (*Larix occidentalis*), is produced chiefly in the region known as the "Inland Empire"—a section of common commercial interests comprising western Montana, northern Idaho, and eastern Washington.

Larch is a close-grained, heavy softwood of moderate strength and stiffness.

The government reports indicate that the factory uses for tamarack and larch, without distinction as to species, are as shown in Table 102.

TABLE 102

FACTORY USES OF TAMARACK

Purpose	Per Cent
Millwork	77
Tanks and Silos	8
Boxes and Crates	6
Paving and Conduits	4
Car Construction	1
Other Uses	4
Total	100

Eastern tamarack is used to a greater or less extent for:

Car construction
Boat floors
Boat keels
Boat stringers
Boxes
Ceiling
Crating
Culm pipe (mines)
Excelsior
Flooring
Interior finish
Molding
Pails
Refrigerators
Ship knees
Silos
Tanks
Tubs
Water pipes
Windmills
Woodwool

Western tamarack or larch is used for general building purposes, interior finish, boat frames, keels, ribs, planking, and decking, door and window casing, fruit and butter boxes, etc.

TUPELO

Tupelo (*Nyssa aquatica*) is one of the softer hardwoods of medium weight, close-grained and difficult to split, but with very good working qualities. It grows chiefly in the cypress regions, and is manufactured and graded by the same interests as cypress. Only in recent years has tupelo come into general notice, but its progress has been rapid, as will be seen from its present factory uses as indicated in Table 103.

TABLE 103

FACTORY USES OF TUPELO

Purpose	Per Cent
Boxes and Crates	58
Millwork	13
Tobacco Boxes	8
Woodenware and Novelties	4
Sewing Machines	3
Laundry Appliances	3
Furniture	3
Agricultural Implements	1
Other Uses	7
Total	100

More detailed uses of tupelo include:

Axles
Balusters
Baskets
Berry cups
Boxes
Brushes
Cabinets
Ceiling
Cigar boxes
Clothespins
Coffins
Crating
Chairs
Excelsior
Felloes
Flooring
Furniture
Hoppers
Hubs
Interior finish
Kitchen safes
Lard dishes
Laundry appliances
Molding
Musical instruments
Ox yokes
Panels (carriage)
Spokes
Table legs.
Tobacco boxes
Trunks
Wagon bottoms
Wagon tongues
Washboards
Woodenware

BLACK WALNUT

The properties of black walnut (*Juglans nigra*) are too well known to need detailed mention. Black walnut is valued for its rich color, fine figure, and susceptibility to high polish. The most prized effects are produced by the careful manufacture of veneer from the burls and apparent deformities of the tree; and raw material of this character is so valuable as to be sold by the pound instead of the ordinary method of measurement.

Considerable of the best black walnut is exported to Europe in log form. The factory uses reported for walnut in the United States are in the proportions indicated in Table 104.

TABLE 104

FACTORY USES OF BLACK WALNUT

Purpose	Per Cent
Sewing Machines	33
Musical Instruments	21
Millwork	19
Furniture and Fixtures	10
Firearms	7
Caskets and Coffins	2
Electrical Machinery and Apparatus	2
Vehicles	2
Car Construction	1
Other Uses	3
Total	100

Black walnut enters more or less into the manufacture of these articles:

Air-gun stocks
Altars
Automobile bodies
Barber chairs
Benches
Billiard cues
Bookcases
Brush backs
Bureaus
Cabinet work
Canes
Card tables
Carpet-sweepers
Carvings
Case work
Caskets
Chairs
Chair legs
China closets
Chiffoniers
Clock cases
Coffins
Couches (legs)
Desks
Doors
Electrical appliances (bases)
Embalming boards
Fixtures (exterior parts)
Fixtures, office
Fixtures, store
Fretwood
Furniture
Gunstocks
Handles
Inlaid work
Interior finish
Machine boxes
Molding
Novelties
Organ cases
Panels (veneered)
Parquetry flooring
Patterns
Pianos
Piano actions
Piano benches

Piano cases
Piano players
Picture frames
Pipe organs
Sash
Sewing machines
Show cases
Sideboards
Side tables
Steering wheels
Stools
Tables
Tool boxes
Umbrella handles
Vehicles
Windshields (automobile)
Woodenware

WILLOW

The wood of the willows which attain tree size is very light and soft, and, while neither stiff nor strong, is tougher than many heavier woods.

Willow lumber is nearly all made from black willow (*Salix nigra*), and finds its largest use in the manufacture of boxes and crates. In bolt form, where abundant, willow is an important source of material for the manufacture of excelsior. Willow is also used in the manufacture of baseball bats, boats, furniture shelving, wagon beds, and artificial limbs.

YUCCA

In the Southwest, especially in Southern California, the yucca (*Yucca arborescens*) attains real tree dimensions, although this plant would not ordinarily be considered a tree at all. It appears that the equivalent of nearly 200,000 feet of lumber is annually manufactured from yucca. The wood is very light in weight, fibrous, tough, and, when wet, pliable and easily molded into desired forms.

Yucca finds its largest use in the manufacture of woodenware and novelties; but a considerable quantity is also used in millwork in California, and, in that state, it is used very much more than any other material in the manufacture of artificial limbs, jackets, surgeon's splints, and corsets.

MINOR SPECIES OF NATIVE WOODS

A few of the numerous other native woods used to a small extent include the following:

Ailanthus, mountain ash, and silver bell, for boxes and crates; blue beech, catalpa, and china tree, for vehicle parts; catalpa, china tree,

kalmia, haw, mesquite, mulberry, and sumac, for furniture; manzanita, mountain lilac, mountain mahogany, and orange, for novelties; mulberry, silver bell, and witch-hazel, for millwork.

Since there are more than 500 tree species in the United States, it is obvious that, so far as numbers are concerned, only a few of them are mentioned in the foregoing pages. No species, however, has been omitted which is a considerable source of lumber supply or of much importance in general commerce. Many of the unmentioned woods are used in a small or local way for a large number of purposes, among which are novelties, turnery, etc.

FOREIGN WOODS

In the aggregate, the equivalent of about 100 million board feet of the more costly woods is used annually in the factories of the United States, principally for the manufacture of furniture and for the finer, more expensive millwork, as well as for various decorative purposes. The total quantity of each of these woods imported is divided among the various industries in about the proportions which are indicated in Table 105.

The only important foreign wood omitted from this table is Spanish cedar, of which about 30 million feet is imported annually and practically all used in the manufacture of cigar boxes.

TABLE 105

Factory Uses of Imported Woods

TURKISH BOXWOOD

Purpose	Per Cent
Whips, Canes, and Umbrellas	88
Firearms	6
Shuttles, Spools, and Bobbins	5
Other Uses	1
Total	100

WEST INDIAN BOXWOOD

Purpose	Per Cent
Professional and Scientific Instruments	75
Shuttles, Spools and Bobbins	12
Musical Instruments	8
Handles	4
Other Uses	1
Total	100

COCOBOLA

Handles	75
Professional and Scientific Instruments	23
Other Uses	2
Total	100

EBONY

Whips, Canes, and Umbrellas	37
Sporting and Athletic Goods	36
Musical Instruments	11
Millwork	9
Brushes	2
Tobacco Pipes	2
Furniture	1
Other Uses	2
Total	100

LIGNUM VITAE

Furniture	62
Sporting and Athletic Goods	25
Pulleys and Conveyors	8
Professional and Scientific Instruments	4
Other Uses	1
Total	100

MAHOGANY

Furniture and Fixtures	47
Musical Instruments	17
Millwork	14
Car Construction	12
Caskets and Coffins	3
Ship and Boat Building	2
Vehicles	1
Other Uses	4
Total	100

PADOUK

Car Construction	52
Millwork	24
Furniture and Fixtures	23
Other Uses	1
Total	100

PRIMA VERA

Furniture and Fixtures	52
Millwork	32
Ship and Boat Building	8
Car Construction	7
Other Uses	1
Total	100

ROSEWOOD

Purpose	Per Cent
Professional and Scientific Instruments	46
Furniture and Fixtures	14
Musical Instruments	10
Car Construction	8
Sporting and Athletic Goods	5
Handles	3
Brushes	3
Bungs and Faucets	2
Artificial Limbs	2
Millwork	1
Carpet-Sweepers	1
Other Uses	5
Total	100

SATINWOOD

Millwork	50
Furniture and Fixtures	34
Musical Instruments	7
Caskets and Coffins	7
Other Uses	2
Total	100

TEAK

Ship and Boat Building	83
Millwork	12
Car Construction	3
Sporting and Athletic Goods	1
Other Uses	1
Total	100

CIRCASSIAN WALNUT

Millwork	43
Furniture and Fixtures	32
Musical Instruments	15
Firearms	3
Ship and Boat Building	1
Sporting and Athletic Goods	1
Carpet-Sweepers	1
Other Uses	4
Total	100

There are annually used on the Pacific Coast several million feet of foreign hardwoods, among the more important of which are Japanese oak and birch, Siberian oak, Philippine mahogany and other species, and Australian eucalyptus. Small quantities of many other foreign woods are also used for a variety of purposes.

Under normal conditions, considerable pine lumber manufactured in northern Mexico is shipped across the border, while a large amount of Canadian white pine lumber and western red cedar shingles is marketed in the United States.

CHAPTER XVII

LUMBER MANUFACTURING*

ACQUISITION OF TIMBER

The lumber manufacturer uses any one or all of three methods to secure the timber for his sawmill. He may purchase land and standing timber; he may purchase standing timber without the land; or he may buy logs cut by others.

Purchase of Timberland

Lumber manufacturers, especially those conducting the larger operations, generally own their supplies of raw material. A modern lumber manufacturing plant may cost from $100,000 to $500,000, or even more. The owners of these plants ordinarily feel it necessary to insure the safety of such an investment by the purchase of a sufficient quantity of standing timber to supply the plant with raw material for a long period. Consequently, the lumber manufacturer often becomes a large land owner.

This is generally true except for portions of Oregon and Washington where some large lumber manufacturing operations are conducted without forest ownership. Here, logging companies either purchase timber land or standing timber only, log the timber, and deliver the logs to the sawmills at a certain price per thousand feet, depending upon species and quality. A number of large logging companies of this character supply many mills on Puget Sound and the Columbia River with raw material.

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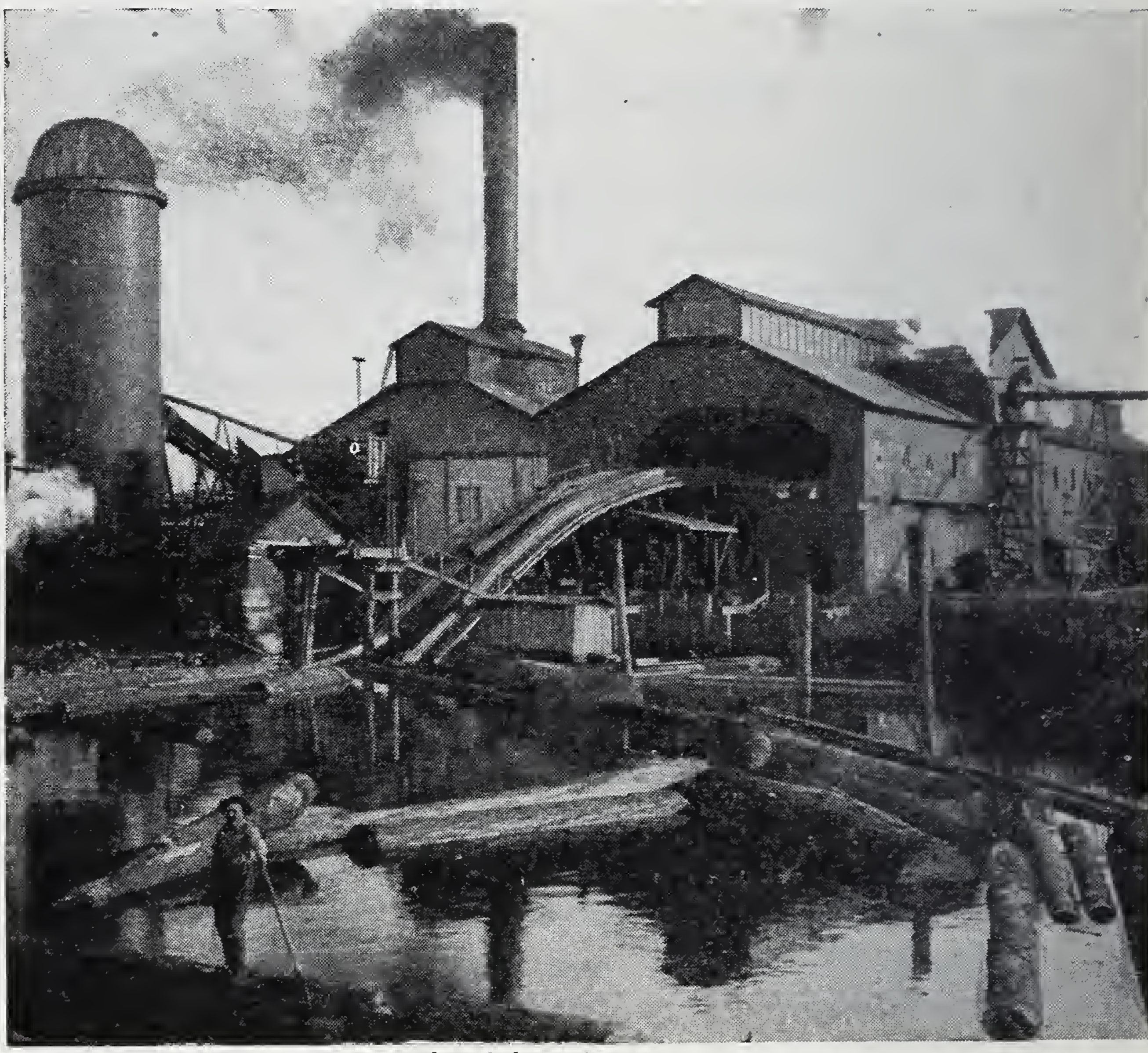
* By permission of the Ronald Press Company, New York, this chapter is condensed from the author's lecture entitled ''The Lumber Industry,'' prepared for the Alexander Hamilton Institute.

Fig. 88.—Old Sawmills in Maine.

These mills, located on tidewater, began operations in 1833.



(Photo by courtesy of Bolling Arthur Johnson)

Fig. 89.—Modern Sawmill at Everett, Washington.

A CONTRAST IN MILLING METHODS.

The lumber manufacturer who purchases timber land usually buys it at a price per acre based upon the stand of timber. Although this price is to some extent a matter of barter, both buyer and seller generally have a more or less accurate report of the kind, character and quantity of timber on the land, based upon a forest survey, or cruise.

Expert cruisers are men of sound judgment and long woods experience, who, with crude but effective methods, examine a tract of timber land, make an estimate of the quantity and quality of stumpage, report upon the lay of the land, and estimate the approximate cost of logging. Buyers and sellers of timber usually have independent cruises made of the tracts under consideration.

Naturally, the buyer of timber land wishes to purchase upon the basis of a conservative cruise in order to have a balance on the right side of his ledger when the timber is cut. For this reason, the amount of lumber actually sawed from a given tract of timber usually exceeds the estimate. Instances in which the production has gone 100 per cent beyond the report of the cruiser are not rare.

Purchase of Stumpage

Although a modern lumber manufacturing plant is not likely to be erected where it must depend entirely upon purchased stumpage without land ownership, it is by no means uncommon for mill operators who own timber land to supplement their supply of raw material by purchasing the standing timber on conveniently located tracts. Stumpage which does not carry with it land ownership is usually bought at an agreed price per thousand feet according to the scale of the timber as cut, and with a fixed time for the removal of the timber.

The owner of the timber may impose a variety of conditions as to the species and size of timber to be cut, methods of logging, brush disposal, fire protection, and so on. A mining company, for example, which considers it essential to hold title to the land, may sell certain classes and sizes of saw log timber and reserve other classes for its own use. A pulp and

FIG. 90.—Bringing in the Logs.

FIG. 91.—Unloading Logs at the Mill.

FIG. 92.—Hauling White Cedar Posts in Winter.

FIG. 93.—Good Train Load of Logs.

FIG. 94.—Dinner Time at Camp.

TYPICAL LUMBERING SCENES.

paper manufacturing concern may cut for its own use suitable pulp timber and sell the other logs to a sawmill operator. A tanning company may purchase a large area of timber land primarily to secure the bark of the hemlock timber for tanning purposes; then, in order to make the most of the investment, the tanning company must either convert the hemlock, hardwood, and other logs into lumber, or sell them to a sawmill operator.

National Forest Stumpage

Within recent years, the National government has become by far the most extensive seller of stumpage. All the merchantable timber that can be cut in the National Forests without endangering the reproductive power of the forests or impairing watershed protection is for sale to the highest bidder under certain restrictions. In cases, also, where the land will unquestionably be of greater value for agriculture than for forest growth, the entire stand is offered for sale; and, after cutting, the land is opened for settlement under the Forest Homestead law.

A timber sale in the Kaniksu National Forest in Idaho is a good illustration of government methods in selling stumpage. Altogether, this timber sale covered approximately eighteen thousand two hundred acres and 240 million feet of timber, together with 180 thousand cedar poles. The saw timber consisted chiefly of white pine, larch, yellow pine, Douglas fir, spruce, and cedar. The lowest stumpage prices the government considered on this tract were $3 to $5 per thousand feet for the white pine; $2 per thousand feet for the yellow pine; and 50 cents per thousand feet for the other species. Stumpage prices for cedar poles ranged from 10 cents to $2.30, depending upon the length and diameter.

The bidder for the timber was required to deposit $10,000 with the bid. The deposit was to apply on the purchase price if the bid be accepted, and refunded in case of rejection. The successful bidder was required to sign a strict and detailed contract which specified the manner in which the timber was to be cut, scaled, removed, and paid for. The buyer must cut

no timber not designated by a forest officer, do no unnecessary damage to young growth, cut low stumps, take the logs into the tops to a minimum diameter, take proper precaution to prevent forest fires, and burn slash as directed by the forest officer.

Moreover, the stumpage prices, starting at the figures mentioned, were upon a sliding scale depending upon the market value of lumber, as the following extract from the contract signed by the purchaser indicates:

> We agree to pay for all timber cut prior to May 1, 1917, at the rates specified above; for all timber cut subsequent to May 1, 1917, and prior to May 1, 1920, at such rates as shall be designated by the Forester on May 1, 1917; for all timber cut subsequent to May 1, 1920, at such rates as shall be designated by the Forester on May 1, 1920; provided, that the rates to be designated upon each of the respective dates shall be determined as follows:
>
> (*a*) For the purpose of this contract it is agreed that the average mill run lumber prices per thousand feet board measure prevailing at the date of execution hereof, F. O. B. cars, at the mills operating in Idaho, north of the Salmon River, and in Washington east of Spokane, are $15 for yellow pine, $20 for white pine, $13 for Englemann spruce, $11 for Douglas fir, larch and lodgepole pine, and $10 for cedar saw timber, and for cedar poles sold in the general market the following rates: 25′ 6″, $1.20; 30′ 6″, $1.47; 30′ 7″, $2; 35′ 7″, $2.80; 35′ 8″, $3.20; 40′ 7″, $3.28; 40′ 8″, $3.70. (Rates for greater lengths to be ascertained and inserted in the final contract.)
>
> (*b*) The Forester shall ascertain the average mill run lumber and the average pole prices prevailing for the various species and dimensions above specified, F. O. B. cars, at the mills and pole yards, respectively operating in the territory above defined during the years ending December 31, 1916 and 1919.
>
> (*c*) If the average price of any species, prevailing during any one of said years specified in (*b*) shows an increase over the price of the same species agreed upon as prevailing at the date of execution hereof, of $2 per thousand feet board measure, or less, for saw timber, or 10 per cent, or less, for poles, no increase shall be made in the stumpage rate for saw timber species or poles as fixed on the following May 1. If the increase in the average price of any species is greater than $2 per thousand feet board measure or 10 per cent for poles, not more than 75 per cent of the amount of such increase in excess of $2 or 10 per cent, respectively, may be, in the discretion of the Forester, added to the stumpage rate for such material as fixed on the following May 1.

The minimum stumpage rates quoted in the notice of sale were determined by deducting from the then existing average

selling prices of lumber the cost of logging, milling, and other expenses plus approximately 12 per cent profit. In commenting upon these terms, the chief of the Forest Service said:

> The 12 per cent profit to the lumbermen allowed for in calculating the stumpage rates to be charged is exclusive of interest on the investment, which was figured at 6 per cent. The minimum prices allowed, therefore, for a profit of 12 per cent on every thousand feet of timber sold, over and above interest on capital and all overhead costs. It must be remembered that the manufacture of lumber is a business which, because of the risks involved, requires a high return in order to induce operators to undertake a logging enterprise.

Purchase of Logs

Many small mills whose annual output runs from only a few hundred thousand to one or two million feet may buy all their logs in the open market. Except on the Pacific Coast, the larger sawmill operators do not commonly depend upon the purchase of logs in this way for their entire supply of raw material. They may, however, supplement their supplies from their own timber through the purchase of logs delivered to their railroad lines or banking grounds, or hauled by farmers direct to the sawmills.

In Washington west of the Cascades many large sawmills depend chiefly or entirely for their raw material upon logs purchased from logging companies. In fact, in this region, perhaps not more than 30 per cent of the lumber manufactured comes from logs cut on land owned by the sawmill operator. The price of logs, of course, fluctuates with the cost of stumpage, supplies, labor, and the condition of the lumber market.

OPERATIONS

Lumber operations normally have four distinct phases; 1—Logging; 2—Transportation of logs to the mill; 3—Manufacture; 4—Marketing. To this may be added, depending upon circumstances, a fifth activity, the making of by-products.

Logging

Logging includes all the processes necessary to convert standing timber into saw logs ready for the journey to the sawmill. There are as many methods of logging as there are varieties of timber and topography. They range from the crudest of operations, in which only hand power is used, to those in which the latest types of steam or electric machinery are employed. The one general principle underlying all logging operations is to utilize gravity wherever, and as fully, as possible. Logs are large, unwieldy, and heavy. They may be slid, pulled, or carried down hill with comparative ease, but only under conditions which admit of no other alternative does the woodsman attempt to transport them up hill.

The logger who cuts only a few trees close to water or beside an existing road may have no well-laid plan of operation, but every lumber manufacturer who undertakes to convert a large body of standing timber into logs and get the logs out finds that he cannot have too much information upon the character and density of the stand, the lay of the land, and the probable cost of logging. Neither can he afford to begin operations without having worked out a clear and comprehensive plan for the handling of the entire tract. Here is where accurate cruises and sketches or topographic maps become most valuable and even necessary. Knowing the kind and quantity of timber on each portion of the tract, the height of ridges and depth of valleys, the grades of slopes, and the course of contour lines, together with soil or rock formations, the modern woodsman, who is really a logging engineer, is enabled to plan in advance the location of his wagon road or railroad, and all branch roads; to determine where skidways and landing shall be; and to decide how each body of timber can be taken out at minimum cost.

The amount of timber to be cut each year depends, of course, upon the capacity of the sawmill to be supplied. A tract may contain only timber enough for a single season's sawing, or it may have sufficient raw material to stock the mill for twenty years. In the latter case, the size and location of the area to be cut over each season is carefully worked out in the manner best suited to the requirements of the operation.

The Logging Camp.—The first essential in a logging operation is to establish camps. It requires a large number of men to do woods work, and ample preparation must be made to care for them far from a base of supplies. The number of men needed varies with the size of timber and the method of logging. It may be said roughly, however, that in the Lake States, under present conditions, not less than one man is required for every 500 feet of logs put on skidways daily. If, therefore, 25 or 50 million feet of logs are put in during a winter, or logging season, a very large number of men must be employed and cared for.

The camps in which these men are fed and housed are generally as rude and cheap as a fair degree of comfort will permit of, but the food must be muscle-building and abundant because woods work is heavy, and the appetites developed in the long days out doors are ravenous. In may ways, the camp cook is the most important man in the operation, for upon him depends whether the men are well fed and satisfied, or poorly fed, grumbling, and constantly quitting work. Camp cooks have reputations which are known far and wide among woodsmen, and a cook who can keep his men well fed and contented and at the same time use supplies economically, is eagerly sought for by woods superintendents.

Camps are located so as to be easily accessible from all parts of the operation so that the men may lose as little time as possible going to and coming from work. Seldom is the most distant cutting more than two miles away from camp. In order to save time also, the noon meal is often taken to the workmen by the cook and his helpers. The number of men to a camp varies greatly, but an average of fifty to one hundred is typical of operations throughout the United States.

Camp buildings may be made of logs, of slabs and rough lumber, or of anything that happens to be cheapest in a particular locality. Sometimes they are completely abandoned when the logging work is finished. In other operations they are made in sections so as to be readily picked up, loaded on cars, and transferred to a new site. A few of the most progressive lumbermen have even gone so far as to build complete camp trains, containing bunk cars, kitchen cars, dining cars, office cars, and even stable cars for the horses. Although

expensive at first, these camps seem to give satisfaction in certain types of railroad logging.

Roads.—Road making is the next step in a logging operation, for without roads logs cannot be started upon their journey to the sawmill. Main roads are opened up by felling trees, digging out, pulling or blasting stumps, cutting down hills, filling hollows, bridging streams and corduroying swamps. Branch roads are opened as successive timber areas are cut over, and the logs made ready for hauling. The laying out of roads is one of the most important features of a logging operation, and in them the ''down hill'' principle is followed to the fullest extent. Men called ''road monkeys'' are employed to keep logging roads in repair.

Cutting.—With camps established and roads made, real logging begins. Felling crews, ordinarily of two men each, cut down the trees. In some operations the fellers also cut up the trees into log lengths; in others they only fell the trees, and the cutting of the prostrate trunks into proper lengths is done by other crews.

In the East, two men with a cross-cut saw usually cut the fallen trees to log lengths. On the Pacific Coast, however, the men generally work singly, using a cross-cut saw with one handle removed. Cutting a tree up in this fashion is called ''bucking,'' and the men who do it, ''buckers.''

While numerous attempt have been made to invent practical tree-felling machinery with which the trees can be felled by power saws driven by steam, gasoline or electricity, little progress has been made in this direction. No real substitute has been found for the axe and cross-cut saw applied with plenty of ''elbow grease.'' In an occasional operation in open, level country, however, it has been found practical to use a comparatively simple pneumatic device operated by a traction engine to cut the fallen trees into log lengths. Such a device has been in use for a number of years by a company in California which manufactures a large amount of western yellow pine.

Skidding.—The next problem is to transport the logs to the first point of assemblage on their way to the mill. This first point is usually called the skidway, and moving the logs from the point of cutting to the skidway is called ''skidding.''

Much axe work is necessary in lopping tops and cutting out brush, so that the logs may be dragged from their resting place to the skidway. This is called "swamping," and the man who does such trimming and clearing is called a "swamper."

Skidding methods vary according to custom, locality, and the character of the timber. The original method, still widely used, is to drag the logs on the ground with horses or oxen. A slight improvement over this is to have one end of the log rest upon a V-shaped structure called a "travoy," made by joining two short timbers together or cut from a forked tree. Another method often used in the comparatively open pine forests of the South, and elsewhere when conditions permit, is to sling the logs under a gigantic pair of wheels pulled by a team of horses. These wheels have wide tires, and may be as much as 10 feet in diameter, so that they pull easily and are not retarded by small obstacles.

Steam power is used in many ways in skidding. In the typical western operation where the country is rough and the timber of immense size, logging is done by "donkey" engines. Heavy steel cables, running upon drums operated by the engines, drag the logs from their resting places to the point of assemblage. In many operations of this character, the logs are first pulled from all directions to a common meeting point or "yard" by one engine, and are then made up into strings and dragged to the railroad track by another.

An adaptation of the donkey engine principle to local conditions is found in the cypress swamps of the South where an engine with drums and cables is mounted upon a flat-bottom boat. This is called a "pull boat." It is used to pull the cypress logs through the swamps and artificial canals in that region. In rough or swampy country the overhead method of skidding operated by so-called "flying machines" is also used. Carriers, swung from overhead cables, raise the logs partly or wholly from the ground, and transport them rapidly to the skidway or, more commonly in these operations, to the railroad track.

On steep hill-sides and mountain slopes, chutes, or slides are used. The logs are brought to the top of the slide by the

most convenient of the methods previously described, and dropped to a yard, pond, or landing, below.

Where water is abundant, a flume constructed of heavy lumber is sometimes used to carry the logs to the point of assemblage. In a few instances, flumes are also used to transport lumber from an otherwise inaccessible sawmill to a shipping point.

Hauling.—In the typical Lake States operations, where modern methods of lumbering were first instituted, logging was originally done in the winter time. The logs were dragged to the skidways by horses and then hauled in great loads on large, heavy sleds to a landing on a river, whence, with the Spring freshets, they were driven down stream to the sawmill. In order to make the going easy, the sled roads were made as smooth as possible and frequently sprinkled with water so that the sleds ran on a bed of ice with the least possible resistance. Because of this, a single team of horses could haul a load of almost unbelievable proportions.

A modern adaptation of this principle of hauling logs on sleds over ice roads is found in the invention and quite extensive use of a steam log hauler—a traction engine of the caterpillar type and peculiar appearance—which hauls a train of loaded sleds both rapidly and cheaply.

While the term landing originally meant the place on the bank of a stream where logs were piled ready for driving in the Spring, its meaning has now been extended to cover the place alongside a railroad track, at which logs are delivered and loaded on cars.

Transportation to the Mill

In the lumber operations of years ago, when the sawmill was surrounded by merchantable timber and the distance between the woods and the mill did not exceed a few miles, horses or oxen were an efficient means of transporting the logs to the mills. When the distance became too great for this, other methods were devised.

Water Transportation.—The first was that of "driving" the logs down a stream. This method is still followed to some

extent, although it is not so universal as in the early days of lumbering. The logs are thrown into the water loose and are carried down stream by the force of the current. Much work is necessary to avert jams, keep the logs in the main channels, and gather up stragglers. Many logs are lost through either being left in shallow places or becoming water-logged and sinking.

A similar, but not so spectacular method, used on lakes and the larger rivers, is "rafting." The logs are assembled in quantity, securely bound together by chains and floated down large streams or towed on lakes or other bodies of water. All the logs are saved unless misfortune overtakes the raft and it is broken up. Like driving, rafting is of less importance at present than formerly throughout the greater part of the United States.

A most notable development of the raft idea has taken place on the Pacific Coast. A large sawmill at San Diego, California, is regularly supplied with logs from the Columbia River region. The logs are formed into cigar-shaped rafts, nine hundred feet long, and towed through the ocean twelve hundred miles from the mouth of the Columbia to San Diego. Each raft contains six million feet. This is commercially possible only because higher prices are realized for the lumber at San Diego, and because of the existing market for all waste material for fuel and other purposes.

Railroad Transportation.—The logging railroad has replaced to a great extent the driving and rafting of logs. Moreover, the use of the railroad has been instrumental in removing sawmills from the banks of the streams and putting them in cities far distant from the timber, where labor is abundant and the local market for lumber and for mill waste as fuel, is large. Many lumber companies become owners and operators of railroad lines of no mean proportions; others ship their logs long distances over commercial lines. The transportation of logs to sawmills more than two hundred miles distant is now not uncommon.

A further point in favor of railroad operations is that logs can be brought to the mill both winter and summer, none of them need be lost in transit, and operations can be conducted with a certainty wholly lacking where the transportation of

logs to the mill depends upon streams and uncertain weather conditions. (Page 320.)

Manufacture

With the logs cut and delivered to the mill pond, the manufacture of lumber begins. This involves sawing to boards or other stock of specified dimensions, edging off the bark, trimming the defective ends, grading the product into standard classes, and piling it in the yard to season. In some operations this last is omitted and the lumber goes straight from the tail of the sawmill to the dry kiln to be artificially seasoned and immediately shipped to market.

Sawing Equipment.—Most of the large modern mills are equipped with band saws. Many older mills and a few new mills have circular saws as their main sawing equipment. Band saws give more evenly sawn lumber with less "saw kerf" or waste in sawdust than circular saws. Production may be more rapid with circular saws, but the quality is likely to be poorer and the waste greater.

In addition to the main saws, whether band or circular, auxiliary sawing apparatus, consisting of resaws or gang saws, is very common. Resaws are ordinarily either upright or horizontal band saws of smaller gauge than the main saws, and produce lumber economically by taking thick stuff from the main saws and cutting it to final size. Gang saws consist of a large number of short, straight saws set upright about an inch apart in a heavy frame, which is moved rapidly up and down. At one operation they cut a large number of boards from a "cant," the two sides of which have previously been "slabbed" by the main saws. The addition of resaws and gang saws greatly increases the output of lumber at a reasonable cost of operation.

Edging.—All boards which have not been cut to uniform widths with square edges by the main saws and resaws pass through the edgers where the bark is cut off and standard widths given. In softwoods, widths are usually in even inches only, but in hardwoods both odd and even widths are common.

Trimming.—Carried along on a series of rollers and endless chains, the boards next reach the trimmers—a set of circular

saws placed in a common line one or two feet apart, each saw being separately attached to a movable arm so that the operation of a lever raises it up to let a board be carried underneath without sawing. The operator of the trimmer must be a man of good judgment and quick eyesight in order to decide accurately the best method of trimming off defects, or cutting to most profitable lengths the constant stream of boards passing on the endless chain in front of him. In the softwoods, lengths of even feet are most common, while the hardwoods are trimmed ordinarily to both odd and even lengths.

Grading.—From the trimmer the boards are carried out on the sorting chain at the tail of the mill where a competent grader chalks upon them characters indicative of the grades to which they belong. This is for the information of the workmen on each side of the chain, each of whom is responsible for taking certain classes from the chain and loading them upon carts or wagons ready to be hauled to the yard.

Piling.—Many different devices are in use for the transportation of the freshly cut lumber from the sorting chain at the mill to the pile in the lumber yard. Four-wheeled, two-horse wagons are generally used where the haul is entirely upon the ground. At many operations, however, tall, wide, wooden tramways extend from the mill through the lumber yard, and two-wheeled trucks, pushed by hand or hauled by a single horse, are commonly used to transport the lumber to the piles. Sometimes small handcars running upon light steel or wooden rails are used. In a few cases, the truck loads of lumber are hauled by electricity—either a storage battery or trolley tractor being used.

The length of time necessary for lumber to remain in pile to reach shipping condition, depends upon the thickness and character of the timber as well as upon the climate. In high altitudes or in arid regions, inch lumber may dry out sufficiently to ship in less than two months; in humid regions near the sea coast, a year may be necessary for the air-drying of lumber.

Quantity of Output.—The amount of lumber produced by a sawmill is extremely variable, depending upon the kind of timber, the nature of the equipment and the efficiency of the management. In round numbers, however, it is fair to expect

that in softwoods a single band mill will saw from a good quality of logs approximately 45,000 feet of lumber of usual thicknesses per ten-hour shift. With the same equipment, the output of hardwood lumber will range from 25,000 to 35,000 feet. A very common type of mill at present is one carrying two bands and a resaw. Such a mill, with the usual mixture of timber, will cut about 100,000 feet of softwood lumber every ten hours when running smoothly.

Marketing

With the lumber in pile, the next problem confronting the manufacturer is that of marketing his stock.

Selling the Entire Cut.—The easiest way to dispose of the mill output is to sell the entire cut for the year at an agreed price per thousand feet for the merchantable product, with another price for the low grade or culls. This method of selling was one of the earliest ones adopted, and is still followed by many of the smaller manufacturers and some of the large ones. It is usually spoken of as ''jobbing'' the cut of the mill, since the cut goes to a jobber or wholesaler who grades out the product and sells it to the best advantage.

Eliminating the Jobber.—Since the wholesaler ordinarily makes a profit, and frequently a very good profit, many manufacturers prefer to market the product themselves. They sell building lumber, lath and shingles to retail lumber dealers over wide stretches of country. They also sell a great deal of material to woodworking factories of different kinds. Sometimes, too, lumber is marketed through commission men for commissions ranging from $5 to $10 per carload, or from 25 to 50 cents per thousand.

The lumber manufacturer who sells to factories and retail yards may have a sufficiently large list of regular customers to market his entire output by correspondence, or he may find it necessary to keep one or more traveling men on the road on a salary or commission basis.

Some of the largest lumber manufacturers in the United States have established retail lumber yards through which they market the bulk of their output direct to individual users of lumber.

Working the Lumber.—In the earlier days of lumber manufacture, all lumber was shipped rough from the sawmill, and worked into flooring, interior finish, and other forms of building material at planning mills located in the towns and cities where the lumber was used. For many years, however, the better equipped lumber plants have operated planing mills of their own. All ordinary building and finishing material can now be ordered direct from the sawmill worked in the fashion desired for any particular job. This enables the lumber manufacturer to supply a much wider variety of trade than he could if he marketed rough lumber only.

Moreover, the shipment of dressed lumber from the producing point effects a very material reduction in freight charges.

Lumber Shipments.—In all inland lumber operations, the unit of shipment is a carload. When a lumber manufacturer speaks of getting an "order," he means that he has sold a carload of lumber. This is an extremely variable quantity, since many types and sizes of cars are furnished to lumber shippers by the railroads. A carload of lumber, therefore, may range from 10,000 feet of heavy hardwoods in a small car to as much as 50 thousand feet of light softwoods in a very large car.

Mills situated on the Great Lakes and on tide water ship a great deal of their product by vessel. The quantity in a cargo shipment varies as greatly as that in a carload shipment. A cargo may consist of 200 thousand or 300 thousand feet, or of several million feet of lumber, depending upon the size of vessel available.

By-Products

By-products of lumber operations are of great magnitude and of increasing importance. The lumber manufacturer who undertakes to utilize all the timber on a given tract will find many trees which are either too small to be made into lumber or which will yield a greater return if utilized in some other fashion. These are turned into railroad ties, fence posts, telephone and electric poles, tanbark, pulpwood and cordwood, either for fuel or distillation.

The usual by-products at a sawmill are: lath, shingles,

pickets or small dimension stock, pulpwood, fuel wood, shavings, and sawdust.

The local market has much to do with the value of sawmill by-products. Mills situated in the woods or at a great distance from good markets may be able to make only lath and shingles in addition to lumber, while mills more favorably located may be able to convert every bit of their waste into a source of profit. Instances are not rare in which the net income from sawmill by-products amounts to as much as $1.50 for every thousand feet of lumber produced.

TENDENCIES OF THE INDUSTRY

Notwithstanding the fact that there are 30,000 to 40,000 sawmills in the United States, most of which operate during a portion or all of every year, the industry exhibits some of the modern tendencies toward concentration. The number of large sawmills is increasing, and their influence is marked.

The proprietors of the big mills complain that prices are set by the thousands of little mills, and this holds true to some extent in local trade. Alert dealers are often able to pick up small stocks at prices that are from $1 to $3 a thousand below the prices asked by the big mills. Many times, however, these small stocks are poorly sawed and cared for.

The Big Mill vs. the Small Mill

The big mills have the best manufacturing facilities and turn out finished products adapted to the needs of consumers. It is the lumber from these mills that goes to distant markets and determines price levels in competition with lumber from other regions. Yellow pine, Douglas fir, and hemlock now meet in Minneapolis and Chicago where white pine once reigned supreme.

It is not necessarily true that a big operation produces cheaply—in fact, it may be otherwise. It is the big mill, backed by a large amount of stumpage, that has the most costly logging equipment and the heaviest charges for taxes, interest, insurance, depreciation, and superintendence. Hence, the big

mill must cut heavily to keep overhead expenses down to a reasonable figure. When the big plant runs at less than full capacity, costs increase. At half capacity the fixed charges are twice as much per unit of product as at full capacity.

The 1920 census report gives some interesting information upon the production of mills of different sizes. It can be summarized as follows:

	Number of Mills	Per Cent Total Cut
Less than 500,000 feet	15,707	9.16
More than 500,000 feet, but less than 5,000,000 feet	6,233	22.63
More than 5,000,000 feet, but less than 10,000,000 feet	507	10.62
More than 10,000,000 feet	795	57.59
	23,242	100.0

The number of mills in the last class mentioned is about one-thirtieth of the total number of mills in the country, yet the output of these mills constitutes nearly three-fifths of the total product. Expressed in another way, two-thirds of the aggregate lumber output in 1920 was produced by 1,302 mills, or only 5.6 per cent of the 23,242 computed to have been in operation. In 1909 mills cutting 10 million feet and over produced as a class 43.09 per cent of the total cut; in 1920 the per cent was 57.59.

The extent to which the big mills determine the production of our chief lumber regions is striking. Washington is our largest lumber-producing state. Here in 1920 the big mills furnished 85 per cent of the product. In Louisiana, the third state in production, the big mills supplied 83 per cent of the total cut. In Texas they furnished 80 per cent, in Wisconsin 70 per cent, in Oregon 76 per cent, in California 85 per cent, and in Minnesota 74 per cent. It is in regions of greatest timber supply that the big mill is built.

After the big mills have finished their operations, the little mills, which cut second growth timber and what remains of the virgin timber only for local needs, come in. Pennsylvania, for example, had 701 mills in 1920 which sawed less than five hundred thousand feet of lumber each—84 per cent of all the mills in the state being in this class. A similar condition prevails in New York and the New England states, but none of

these states produces as much lumber as is consumed within its borders.

Excess Mill Capacity

Just how much potential production of lumber exceeds consumption, cannot be said, but it certainly amounts to from 25 to 50 per cent. To take a case with which the writer is familiar: Forty mills in Wisconsin and Northern Michigan in 1910 sold some 660,000,000 feet of lumber. The combined daily (ten-hour) capacity of these forty mills was 3,480,000 feet. To produce 660,000,000 feet of lumber would, therefore, require one hundred and ninety days of operation at full capacity, or 7.3 months of twenty-six working days each. Allowing for breakdowns and necessary repairs, these forty mills should be able to saw in eight months all the lumber they sold in 1910. This means that on the average these mills were either idle during four months of the year, or they operated at less than full capacity for more than eight months. In either event, the overhead charges per unit of production were greater than they would be at a plant run at full capacity throughout the year.

Economies in Production

Although the lumber industry is called a most wasteful one by the conservationist who sees in lumbering only the depletion of the country's timber supply, it is by no means so wasteful as it appears. That there is still a great deal of waste is due very much more to the lack of a market for the waste material than to inefficiency in the manufacturing operation. It is probably true that the general development of economical methods of production has been about as great in the lumber industry as in other leading manufacturing operations.

Perhaps too great sacrifices are made to secure rapidity of operation and quantity of output, but the modern sawmill gets very much more lumber out of a log than did its predecessor. Stumps are cut lower than formerly, very much poorer logs are taken to the mill, thinner saws are used, smaller slabs are made, more widths and thicknesses and shorter

lengths go into standard products, and the great diversification of grades takes in much lumber that formerly was considered too poor to market at all.

The superseding of the old, coarse circular saw by the modern narrow-gauged band saw has made a great saving in material and has produced a better grade of product. The resawing of slabs reclaims much narrow lumber of good quality that formerly went to the burner. The general manufacture of lath, dimension stock, and other small forms from slabs and edgings is a common economy which is often profitable.

There has been no lack of invention of devices for converting trees into lumber economically, and the modern lumberman stands ready to avail himself of these devices just as fast as he can find a market for their products.

Fuller Utilization

The report of the National Conservation Commission indicates that only 25 to 50 per cent of the total quantity of the wood in a tree reaches the ultimate user. Large and freely acknowledged waste occurs in logging, sawing, and reworking timber to final forms for service. This, however, should not be charged to the indifference or ignorance of either producer or consumer. Often the entire capital of the lumberman, together with all the funds that he can borrow, is invested in timber. Under these circumstances, he makes every effort he can to utilize his timber closely and get a profit from his stumpage.

The greatest obstacle in the way of fuller utilization in the United States is now, and always has been, the cheapness of wood material. With a large supply of standing timber of great variety to draw upon, we have used wood freely and even extravagantly for a multitude of purposes. Wood has been so plentiful that we have not been driven by necessity into using it economically. The timber-using public has for years taken the cream and refused to look at the skim milk. Consequently, the owner of the skim milk could do nothing but throw it away.

Every advance in lumber prices makes it possible for the lumberman to institute more economies in his operation, and

to sell grades of timber which formerly were of necessity left to rot in the woods. Moreover, much depends upon the location of the sawmill. One situated in the woods, distant from centers of consumption, may be able to ship only its lumber, while a mill situated in a city may find a ready and profitable market for every scrap of the material that the other mill could do nothing with but run into the burner.

CHAPTER XVIII

FOREST PRODUCTS*

The annual wood consumption in the United States takes from our forests approximately 26 billion cubic feet of wood, allowing for the waste which occurs in logging and milling operations. In round numbers, we use yearly 110 million cords of fuel-wood, 40.7 billion feet of lumber (average for 1909–1918), about 9 billion shingles, over a billion posts, poles, and fence rails, 87.5 million hewed cross ties, 1¼ billion staves, more than 80 million sets of heading, nearly 350 million barrel hoops, over 4½ million cords of domestic pulpwood, 250 million cubic feet of round mine timbers, over 1½ million cords of wood for distillation, and more than a million cords of bark and wood for tanning extract.

LUMBER

The manufacture of lumber constitutes by far the largest single use of the forest. Big and little, there are 40,000 sawmills in the United States. The making of lumber and timber products gives employment to more labor than any other industry in the country; it ranks second in the value added by manufacture, being exceeded by foundry and machine shop products; and ranks fifth in the value of products, since it is ranked by the meat packing and slaughtering, iron and steel, flour and grist mill, and foundry and machine shop industries.

According to the Census of 1910, which was by far the best canvass ever made of the industry, the total lumber production in 1909 was 44,509,761,000 board feet, by 48,112 mills. In 1920 the computed quantity cut was 33,798,800,000 feet; the

* All statistics and estimates in this chapter are based upon conditions which existed prior to the entry of the United States into the war.

number of mills operating was 23,242. This was 27 per cent less than the peak production in 1907. Arranged in the rank of production, the output of the states which cut over one billion feet each, and the number of mills reporting, were as indicated in Table 106.

TABLE 106

NUMBER AND OUTPUT OF SAWMILLS IN THE UNITED STATES

(Census of 1920)

States	No. of Sawmills	Million Board Feet
Washington	584	5,525
Oregon	659	3,316
Louisiana	271	2,720
Mississippi	648	1,677
California	195	1,482
Texas	232	1,177
Arkansas	656	1,148
Alabama	903	1,108
Wisconsin	350	1,037

As nearly as can be estimated, the present cut of lumber and related products from the leading species of timber, and the states in which each is chiefly manufactured are indicated in Table 107.

TABLE 107

APPROXIMATE ANNUAL LUMBER PRODUCTION

Species	*Million Bd. Ft.*	*Per Cent*	*Most Largely Produced in:*
Yellow Pine	11,000	32.61	La., Miss., Tex., Ala., Fla., Ark.
Douglas Fir	7,000	20.75	Wash., Oreg., Calif., Ida., Mont.
Oak	2,500	7.41	Ark., Tenn., W. Va., Ky., Miss.
Western Yellow Pine	2,300	6.82	Oreg., Calif., Ida., Wash., Mont.
Hemlock	1,850	5.48	Wash., Wis., Mich., Penna., Oreg.
White Pine	1,500	4.45	Minn., Ida., Me., N. H., Wis.
Maple	875	2.59	Mich., Wis., N. Y., W. Va., Penn.
Gum	850	2.52	Ark., Miss., La., Tenn., Ala., S. C.
Spruce	825	2.45	Wash., Oreg., Me., W. Va., N. H.
Cypress	625	1.85	La., Fla., Ga., Mo., S. C., Ark.
Redwood	480	1.42	Calif.
Chestnut	475	1.41	W. Va., Va., N. C., Penn., Tenn.
Birch	405	1.20	Wis., Mich., N. Y., Me., Vt.
Larch	390	1.16	Ida., Mont., Wash., Oreg., Mich.

TABLE 107—*Continued*

Species	*Million Bd. Ft.*	*Per Cent*	*Most Largely Produced in:*
Yellow Poplar	350	1.04	W. Va., Tenn., Va., Ky., N. C.
Beech	325	.96	N. Y., Mich., Penn., Ind., W. Va.
White Fir	280	.83	Calif., Ida., Wash., Mont., Oreg.
Cedar	260	.77	Wash., Calif., Oreg., Ida., Tenn.
Elm	225	.67	Wis., Mich., Ark., Ind., Ohio.
Basswood	195	.58	Wis., Mich., W. Va., N. Y., N. C.
Tupelo	180	.53	La., Ala., S. C., Miss., Ark., Va.
Ash	170	.50	La., Ark., Wis., Ind., Tenn., Ohio.
Cottonwood	155	.46	Minn., Miss., Ark., La., Wis., Mo.
Hickory	150	.45	Ark., Tenn., Ky., W. Va., Ind.
Sugar Pine	146	.43	Calif., Oreg.
Balsam Fir	85	.25	Me., Wis., Minn., Mich., Vt.
Walnut	35	.10	Mo., Ohio, Ind., Ill., Ky., Iowa.
Lodgepole Pine	31	.09	Mont., Colo., Wyo.
Sycamore	31	.09	Ark., Ind., Miss., Mo., Tenn., Ky.
Cherry	8.5		W. Va., N. Y., Penna., Ohio, Ind.
Willow	7.5		La., Miss., Ark., N. Y., Wis., Va.
Noble Fir	6.5		Oreg.
Pecan	4.0		La., Ark., Miss., Okla., Tenn., Ill.
Buckeye	4.0		Tenn., N. C., Va., W. Va., Ky.
Magnolia	4.0		La., Miss., Tex., Ga., Ala.
Hackberry	2.0		Ark., Miss., La., Ind., Ill., Okla.
Locust	2.0	.13	Penna., Ind., Ark., La., Md.
Alder	1.5		Wash., Oreg.
Butternut	0.5		W. Va., Wis., Ind., N. Y., Va., Vt.
Cucumber	0.5		W. Va., Penn., N. Y., Ohio, Tenn.
Dogwood	0.5		Fla., Miss.
Laurel	0.5		Calif.
Persimmon	0.5		Ark., S. C., Fla., Miss., Ga., Mo.
Total	33,735.5	100.00	

The computed quantity of lumber produced by 10-year periods in the four leading regions since 1850 is shown graphically in Fig. 95 (page 342).

VENEER

The manufacture of veneer has developed greatly in the last few years, and will undoubtedly increase in the future, since the uses for thin lumber are rapidly expanding. While much high-class veneer is used for furniture, musical instru-

ments, etc., there is a growing demand for thicker veneer for the manufacture of boxes, crates, baskets, cases, drawer bottoms and the like. This explains the large amount of veneer

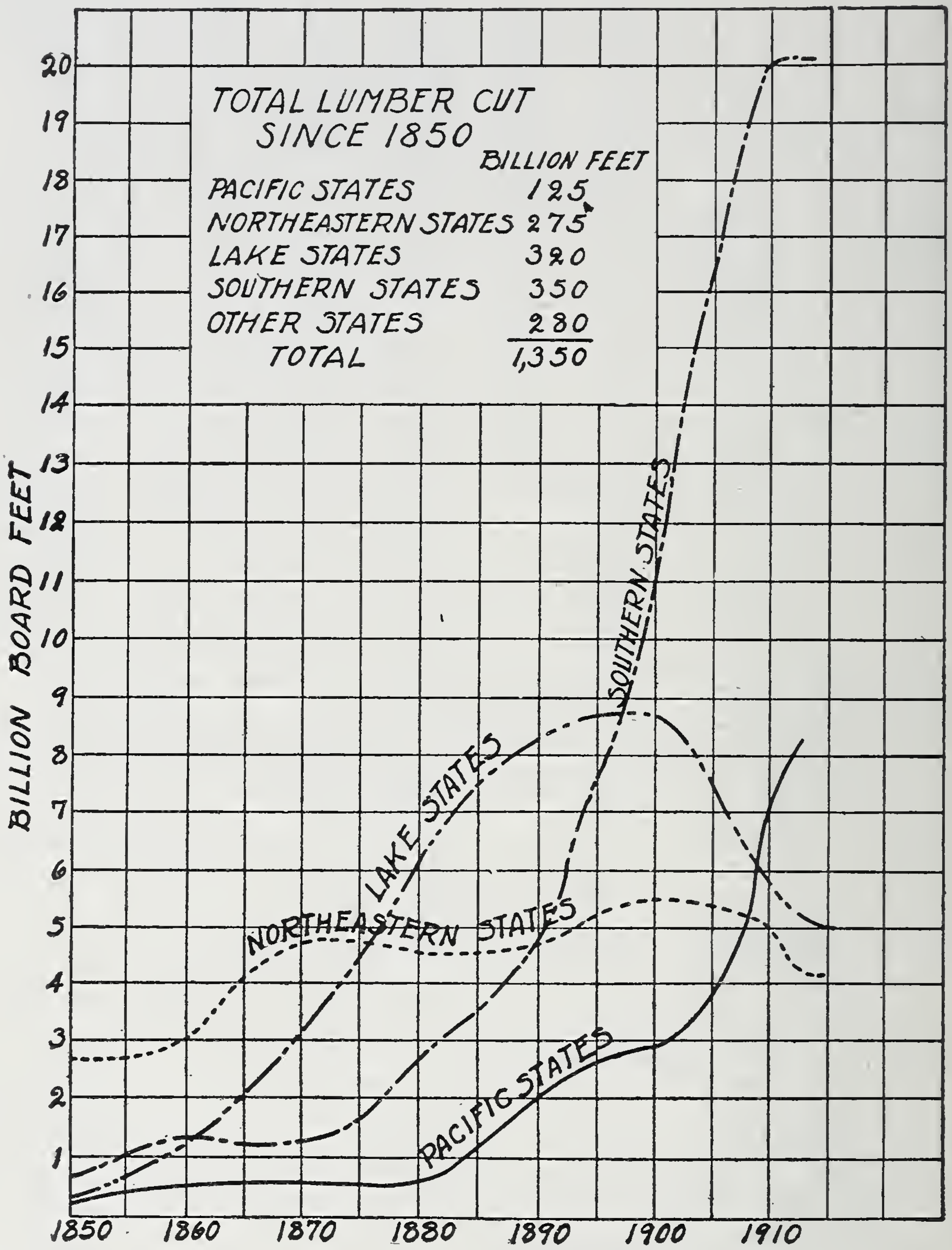


FIG. 95.

made from such woods as yellow pine and cottonwood. According to government reports, the amount of native timber used for veneer in the United States in 1919 was as indicated in Table 108.

SHINGLES

Closely connected with lumber production is that of shingle manufacture. The census of 1920 reported the shingle output to be as shown in Table 109. Shingle production has decreased about 60 per cent since 1905. Washington and Oregon have for many years held the lead in shingle production and their combined cut in 1920 was 83 per cent of that for the entire country. Practically all of the shingles cut in Washington and Oregon are of Western red cedar.

TABLE 108

Wood Used for Veneer in the United States

(Census 1919)

Species	M. Feet
Red Gum	198,641
Yellow Pine	67,071
Birch	54,079
Cottonwood	36,739
Tupelo	34,175
Yellow Poplar	32,653
White Oak	30,654
Maple	15,723
Walnut	14,060
Spruce	11,355
Basswood	11,134
Douglas Fir	10,604
Elm	9,578
Beech	3,923
Ash	3,254
Red Oak	3,161
Cypress	1,924
Sycamore	1,802
Western Pine	1,659
Hemlock	916
Magnolia	268
All Other	783
Total	544,155

TABLE 109

PRODUCTION OF SHINGLES IN THE UNITED STATES

(Census 1920)

State	Shingles Thousands of Pieces
Washington	4,847,105
Oregon	288,721
Louisiana	211,503
California	167,130
Maine	140,038
Michigan	116,678
Florida	67,689
Wisconsin	64,479
Georgia	59,058
North Carolina	47,403
Alabama	32,615
Idaho	25,211
Mississippi	22,858
Arkansas	19,770
All other states	46,158
Total	6,156,416

OTHER PRODUCTS

Cross-ties are cut chiefly from oak, yellow pine, Douglas fir, cedar, chestnut, cypress, tamarack, Western pine, and lodgepole pine, in the order named, with 72 per cent of the total supplied by oak, yellow pine, and Douglas fir. Spruce, hemlock, and balsam fir form the leading pulpwoods. Slack barrel staves and heads are chiefly made from red gum, yellow pine, elm, ash, and beech; hoops, from elm; tight barrel staves and heads, from white and red oak and gum. Two-thirds of the telephone and electric poles are of cedar, and the rest chiefly chestnut, pine, oak, and cypress. Wood alcohol is made by the destructive distillation of birch, beech, and maple; turpentine and rosin, by tapping longleaf pine trees and the distillation of the wood; and tannin is obtained from hemlock and oak bark and chestnut wood.

CHAPTER XIX

THE TIMBER SUPPLY

FOREST REGIONS

Botanists and foresters subdivide the United States into five great forest regions characterized by fairly definite forest types. These are the Northern, Central, Southern, Rocky Mountain, and Pacific regions.

The Northern Forest.—The Northern forest type extends from Maine across New England, New York, Michigan, and Wisconsin, to western Minnesota, with a prolongation down the southern Appalachians to the northern edge of Georgia. Originally the coniferous type predominated in the Northern forests, and by far the most important species was white pine. Next to white pine, ranked hemlock, which was especially abundant in Pennsylvania, Michigan, and Wisconsin; and associated with these species was Norway pine, spruce, cedar, balsam, and a large variety of hardwoods, the most important of which were maple, birch, basswood, beech, ash, and elm.

The Southern Forest.—Starting in New Jersey, and extending to the south and west over practically all of the Atlantic and Gulf States to Texas, with a prolongation up from Texas across Arkansas to Southern Missouri, is the Southern type of forest, in which the yellow pines predominate, with longleaf pine the most abundant of any single species. In many localities within the pine belt, hardwoods are plentiful, especially the gums; while in the swampier regions, and particularly in Louisiana and Florida, large quantities of cypress are found.

The Hardwood Forest.—Lying between the Northern and Southern Forest, and reaching from the Atlantic seaboard to the Missouri river, is a great, irregular region in which the hardwoods abound to the exclusion of other species. It was

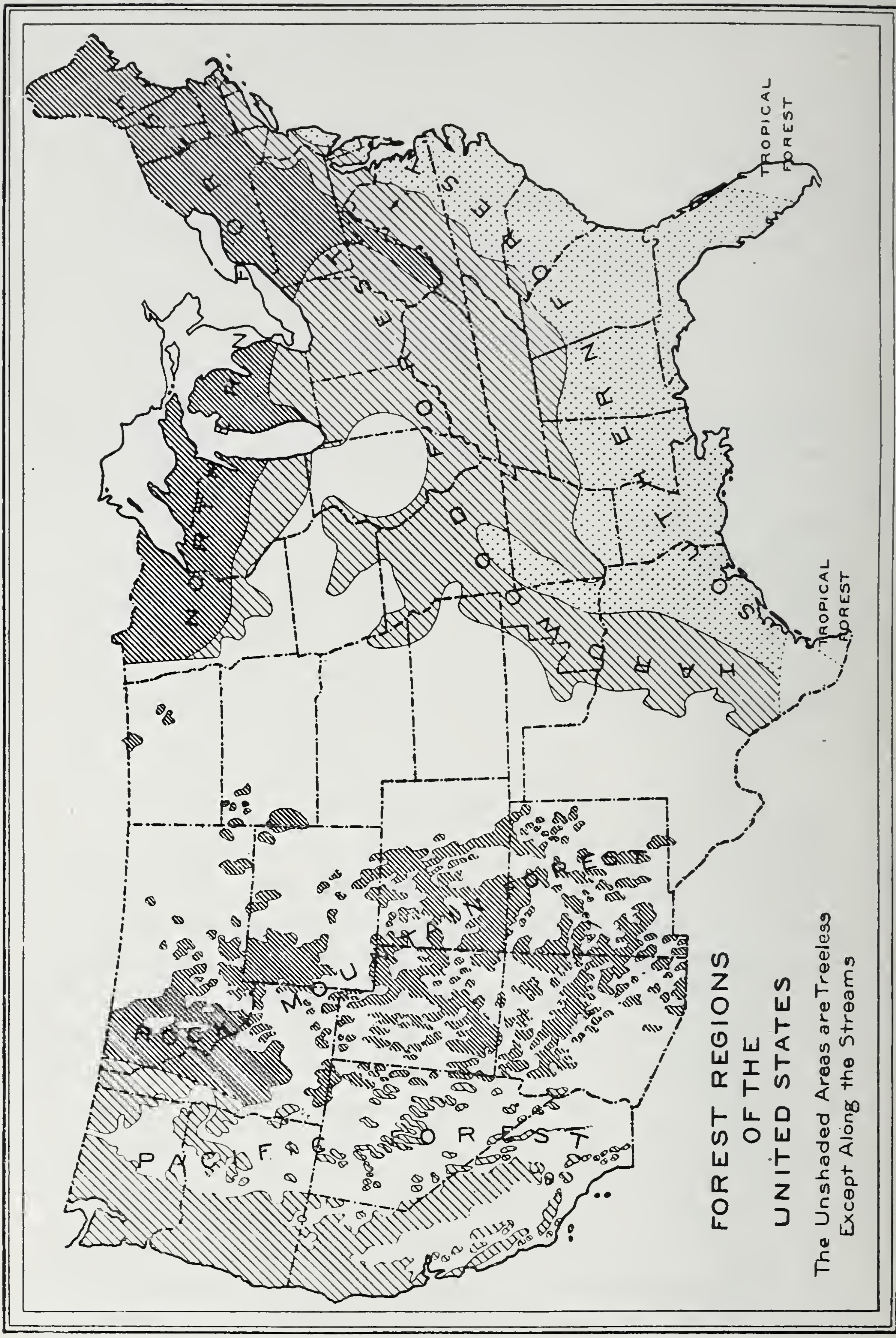

FOREST REGIONS
OF THE
UNITED STATES
The Unshaded Areas are Treeless
Except Along the Streams
TROPICAL FOREST
TROPICAL FOREST

FIG. 96.

here that the oaks, elms, hickories, walnut, yellow poplar, sycamore and other hardwoods were originally most abundant and attained their finest development. It is here, also, that the clearing of forests for agricultural development has gone the farthest, since hardwoods are generally found upon the richest types of agricultural soils. However, the farm woodlots and many areas of larger size in this region still yield much timber for local use, and considerable for shipment to more distant markets.

The Rocky Mountain Forest.—Passing over the vast forestless area of the prairies and plains, we come to the Rocky Mountain region, with coniferous forests on most of its higher mountain slopes and plateaus. The bulk of the timber in these forests consists of Western yellow pine, with other pines, firs, and spruces, and—in the northern Rocky Mountain region—considerable quantities of larch, Western hemlock, cedar, and Western white pine.

The Pacific Forest.—On the Pacific Coast are found the heaviest stands of timber, and the largest individual trees ever recorded in history or revealed by geological strata. From the summits of the Cascades to the Pacific ocean in Oregon and Washington, and on the Coast range and the Sierras of California, are giant firs, cedars, spruces, redwoods, and pines. which for many years to come will be the most important source of timber supply for a large portion of the United States.

The forest regions are outlined in Fig. 96, page 346.

AREA AND STAND

The latest estimates indicate that the forest areas and the quantity of standing saw timber available according to present standards of utilization are not less than the amounts shown in Table 110.*

* Data compiled by the Forest Service in 1920.

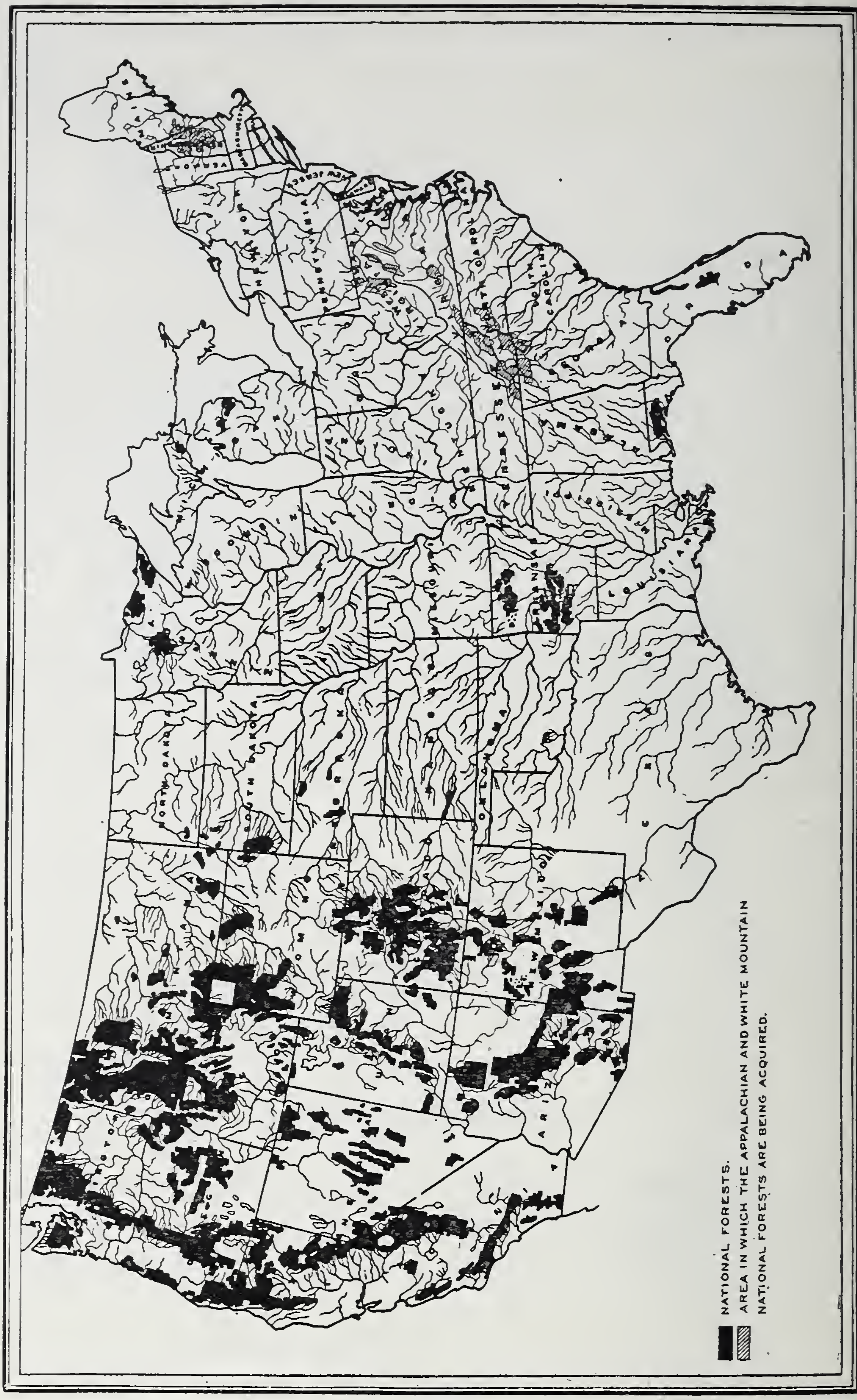


Fig. 97.—Map Showing Location of National Forests.

TABLE 110

Forest Areas and Quantity of Standing Saw Timber in the United States

	Acres	Million Feet
New England	24,708,000	49,799
Middle Atlantic	28,678,000	44,857
Lake	57,100,000	110,110
Central	56,682,000	144,470
So. Atlantic and East Gulf	99,000,000	220,577
Lower Mississippi	78,865,000	280,908
Rocky Mountain	60,842,000	223,141
Pacific Coast	57,586,000	1,141,031
Total	463,461,000	2,214,893

As nearly as can be estimated on the basis of present knowledge, our 2,215 billion feet of standing timber is divided among the various species as indicated in Table 111.

TABLE 111

Quanity of Standing Saw Timber of Various Species

Species	Million Feet
Douglas Fir	595,505
Southern Pine	257,691
Western Pine	249,578
Western Hemlock	95,092
Redwood	72,208
Western White and Sugar Pine	57,071
Western Red Cedar	53,348
Lodgepole Pine	43,319
Hardwoods	459,675
Other	330,806
Total	2,214,893

FOREST OWNERSHIP

Three main types of ownership hold our 463 million acres of forest land. These are public forests, farm woodlots, and the larger private holdings. Public forests include the State and

National Forests and Parks, and timber on the unreserved public domain and on military and Indian reservations.

The National Forests contain about 95 million acres of timbered land, and are chiefly in the Rocky Mountain and Pacific States. They were created by the withdrawal of public land from private entry and sale. Within the last few years, however, the National Government has entered upon the policy of purchasing timber lands in the Eastern mountains, where forest growth is considered necessary for the protection of watersheds at the heads of navigable streams. Under this policy, extensive purchases of forest land (chiefly cut over) are being made in the White Mountains and the southern Appalachians.

The principal state forests are in the East. New York has approximately 2,000,000 acres in its state parks. Pennsylvania has about 1,500,000 acres on forest reserves; Wisconsin, some 400,000 acres; and a few other States, comparatively small forest reservations.

The farm woodlots amount to about 190 million acres. As their name implies, these tracts are chiefly the smaller areas of timber land owned by the farmers in the eastern half of the United States. They average, perhaps, 30 acres in area, and, while not a large source of commercial timber supply, are very important for local use. The Census placed the value of their output in 1909 at 195 million dollars.

The third type of forest ownership is that of the larger private holdings, amounting to about 216 million acres, and contains at least 75 per cent of the merchantable standing timber in the country. Naturally, these holdings in general contain the best of the standing timber in the United States, since private capital always seeks the best investment.

A TIMBER FAMINE?

There has been much talk to the effect that a timber famine is impending in the United States. Whether this is true or not depends entirely upon what is meant by the term famine. If it means that our timber supply will be completely exhausted in 30, 40, 50, or even 100 years, then we can say positively that there will be no timber famine. If, on the other

hand, the term means that, compared with present conditions, our supply of standing timber will be reduced, and the price of lumber higher within the lifetime of men now living, then we can say with equal truthfulness that there will be a timber famine. The question is purely a relative one. Up to the present time, timber of almost every species and grade has been cheap and abundant. In the future, some kinds will be scarcer, and some grades higher priced. On the other hand, there will be a comparatively large supply of the common grades of building lumber for many years, and the competition of other materials will be a strong factor in holding prices to a level which will make most forest products available for a multitude of purposes.

Such data as can be secured indicate that the amount of saw timber now standing in the United States, estimated at 2,215 billion feet, is under one-half the quantity that existed in the country before clearing for settlement and cutting for lumber began. Our annual consumption of sawed timber products now averages approximately 50 billion feet a year. If the stand is 2,215 billion feet, it furnishes cutting for 44 years at the present rate. As a matter of fact, however, more than 2,215 billion feet of lumber will be sawed from the present stand of timber. In some regions there will also be no inconsiderable increment through natural reproduction or growth. Our annual per capita consumption of lumber, which declined to 300 board feet in 1918, from 500 in 1907, may eventually drop somewhere near to the German level of only 48 board feet. This will greatly reduce the demand upon our remaining supply of timber, and help make it sufficient for all legitimate needs.

These statements do not imply that there should be any lack of effort to protect our forest resources. On the contrary, they require the expenditure of great sums of money and years of patient care to bring them into proper condition. The conservation of our natural resources means making the best possible present use of them, while safeguarding their reproductive power for the future. Fortunately, our forest resources are easily reproducible. The question of forestry is largely one of the best utilization of land surface. Land which will yield the highest return under agriculture will, through

economic development, find its use in agriculture. Land which will yield the best return when forested—and this includes land chiefly incapable of ordinary forms of cultivation—will ultimately be the source of our timber supply.

So far as present knowledge permits the classification, it is believed that our forest area of 463 million acres contains 137 million acres of virgin timber; 250 million acres partially cut and burned over, on which there is sufficient natural reproduction to insure a fair second growth; and, finally, 75 million acres so severely cut and burned that, unless supplemented by planting, there will be no succeeding forest of commercial value.

Our potential forest area is large enough to supply all the timber of every kind that we need if it is rightly handled. Here is a field which for years to come will afford great opportunity for the activities of both statesmen and foresters. Although four-fifths of the present timber supply is privately owned, it is highly probable that 100 years hence the bulk of the timber then existing will be in public forests. Because of the long-time investment required, the hazard involved, and the relatively low interest rate obtained from forestry, private capital is not likely to engage in timber growing on a large scale. This makes it necessary that eventually the National and State Governments shall become the more important timber owners.

CHAPTER XX

PERMANENT ADVANTAGES OF WOOD

The clever and persistent advertising given to many substitutes for wood and timber might lead the reader to think that in a few years lumber will be either unnecessary or unobtainable. Wooden sidewalks went out of fashion long ago; wooden buildings and shingle roofs are not permitted in restricted sections of cities; boxes of paper and fiber are used in place of boxes formerly made of boards; steel passenger and freight cars and concrete culverts and bridges are common; while structures of concrete, brick, or tile are found on the farms, and steel row-boats glide about the pleasure parks. As a matter of fact, wood has been so cheap and abundant in the United States that it has been used for a multitude of temporary purposes, and often for purposes for which other products are better suited.

Another stage of economic development has now been reached. Wood is taking its place as one of the finer materials, and the coarser uses are being given over to coarser products. This makes it possible to have a relatively larger supply of wood for the purposes for which it is unquestionably the most suitable material. No doubt, also, some of the present use of substitutes is a temporary fad, and public favor will eventually return sensibly to the earlier material. An instance of this was the construction of the all-metal box car and the all-metal sleeping car for a number of years. Time demonstrated that wood was, in part, more suitable and economical than all metal so that present day practice generally calls for an all-steel underframe car with a wood body.

The permanent advantages offered by wood may be summed up as follows:

(1) Its general availability. Wood is a natural product more widely distributed and more easily obtainable than any other structural material

which the earth affords. The multiplicity of purposes for which it is used is surprising, even to those best informed upon the subject. A study of the wood-using industries of Illinois showed that in the factories of that state white oak is used for 276 distinct purposes; that hard maple has 164 functions in these same factories; that birch is used in the manufacture of 154 different articles; and that red oak, longleaf pine, red gum, yellow poplar, white pine, and basswood are each used for 100 to 140 different purposes. Moreover, the new uses developed for wood yearly through discovery and invention, offset to some extent the lessened demand because of substitutes in other directions. For example, the use of wood block paving created a considerable demand.

(2) Wooden structures can be altered and moved, or built over, more easily and cheaply than can structures of any other material.

(3) Wood is very strong for its weight, compared with other structural materials. The average weight of the woods ordinarily used is some 30 pounds per cubic foot; that of iron and steel is 14 to 15 times as much. This is a great advantage in handling. A bar of hickory greatly surpasses in tensile strength a bar of steel of the same weight and length. Similarly, a block of hickory or longleaf pine will sustain a much greater weight in compression than a block of wrought iron of the same height and weight. Indeed, practically any piece of sound, straight-grained, dry wood is stronger than steel, weight for weight. Moreover, wood will sustain a far greater distortion of shape than metal without suffering permanent injury; while, of course, no such distortion can be sustained by either concrete or clay products.

(4) Wood is easily worked with common tools, while to work the metals requires special tools and much power and time. Anyone with saw and plane and auger can build a structure of wood; an iron-worker is a skilled mechanic whose services come high.

(5) Wood is a non-conductor of heat and electricity, as compared with metal; and of moisture, as compared with ordinary concrete and brick. These are points for serious consideration in home building. They also explain why we prefer to sit on wooden seats, work at wooden desks, and eat at wooden tables.

(6) Wood does not contract and expand with changes of temperature, while its tendency to shrink and swell with atmospheric conditions can be completely overcome by proper seasoning and painting; hence wood can be made to "stay where it is put."

(7) Wood has a varied and beautiful figure with which no other material can hope to compete, for furniture, house trim, and general decorative purposes. It gives a comfortable, homey atmosphere that can be obtained in no other way.

(8) Wood offers a combination of strength, toughness, and elasticity not possessed by any other material. Imagine, if one can, a baseball bat, a golf club, or an ax handle of anything but wood.

No matter how great may be the inroads of substitutes, wood will continue to be an essential component of articles of

necessity, of luxury, and of sport. We shall always have it with us, and such increase in its cost as may be brought about by natural causes will only serve to make the many intrinsic qualities of wood more highly appreciated.

CHAPTER XXI

SOURCES OF INFORMATION ABOUT TIMBER

The general public has little idea of our timber supply, and even the manufacturers and users of forest products have no conception of the abundance of information that can be obtained simply for the asking. The Forest Service of the United States Department of Agriculture has for many years collected information upon the forest resources of the United States, and upon the properties and uses of wood, which is freely given to all inquirers. Moreover, the several associations of lumber manufacturers throughout the country freely supply information upon their own particular products.

ASSOCIATIONS OF LUMBER MANUFACTURERS

The more important of the associations of lumber manufacturers, together with their headquarters and the woods with which they deal, are given on page 43. In addition to setting standards for lumber grades and sizes, these associations are valuable sources of information upon trade customs and the uses of lumber. They are not selling organizations; but an inquiry directed to them will promptly bring a reply stating where and of whom any given product may be purchased. Several of the associations conduct extensive advertising campaigns to increase the demand for their products; and from them the prospective timber user may obtain a great deal of interesting information put up in attractive form, as well as samples of the various woods, from which their quality and structure may be judged.

THE NATIONAL FORESTS

The National Forests contain one-fifth of the present timber supply of the United States, and will become increasingly im-

portant as time goes on, since they are so managed as to insure a permanent timber crop. All timber which can be cut from the National Forests without impairing watershed protection, or a future crop of timber, is freely offered for sale. The location of these forests is indicated on the map on page 347. The magnitude of the government timber holdings, and their potential supply of forest products, are but little appreciated by the general public. Every forest is in charge of local officers, who execute the regulations as to timber cutting, stock grazing, etc., and among whose chief duties is the production of the timber from fire.

The National Forests are divided into six main groups for administrative purposes. Inquiries concerning them may be addressed in each case to the District Forester nearest to the locality in question. The district offices are at the following points: Missoula, Mont.; Denver, Colo.; Albuquerque, N. M.; Ogden, Utah; San Francisco, Cal.; and Portland, Ore.

FOREST SERVICE RESEARCH

At Madison, Wis., the Forest Service operates, in co-operation with the University of Wisconsin, a large and completely equipped laboratory, known as the Forest Products Laboratory, in which are carried on many investigations and a great deal of research relating to the properties and uses of commercial woods.

Without going into details, it can be said that the laboratory is thoroughly equipped with all the machinery and scientific appliances necessary to carry on the following lines of investigation, as well as several others:

Mechanical Properties of Timber

Mechanical tests of timber are highly valuable to engineers, manufacturers, and other users of wood, since they enable the man who specifies timber for a particular purpose to know exactly the properties of the material he is dealing with.

The first series of mechanical tests is upon small, clear sticks of all the leading species, which gives a reliable basis for the comparison of their strength, weight, and other properties.

The second series of tests is upon timbers of the quality and sizes commonly used in bridges and general building construction. The pur-

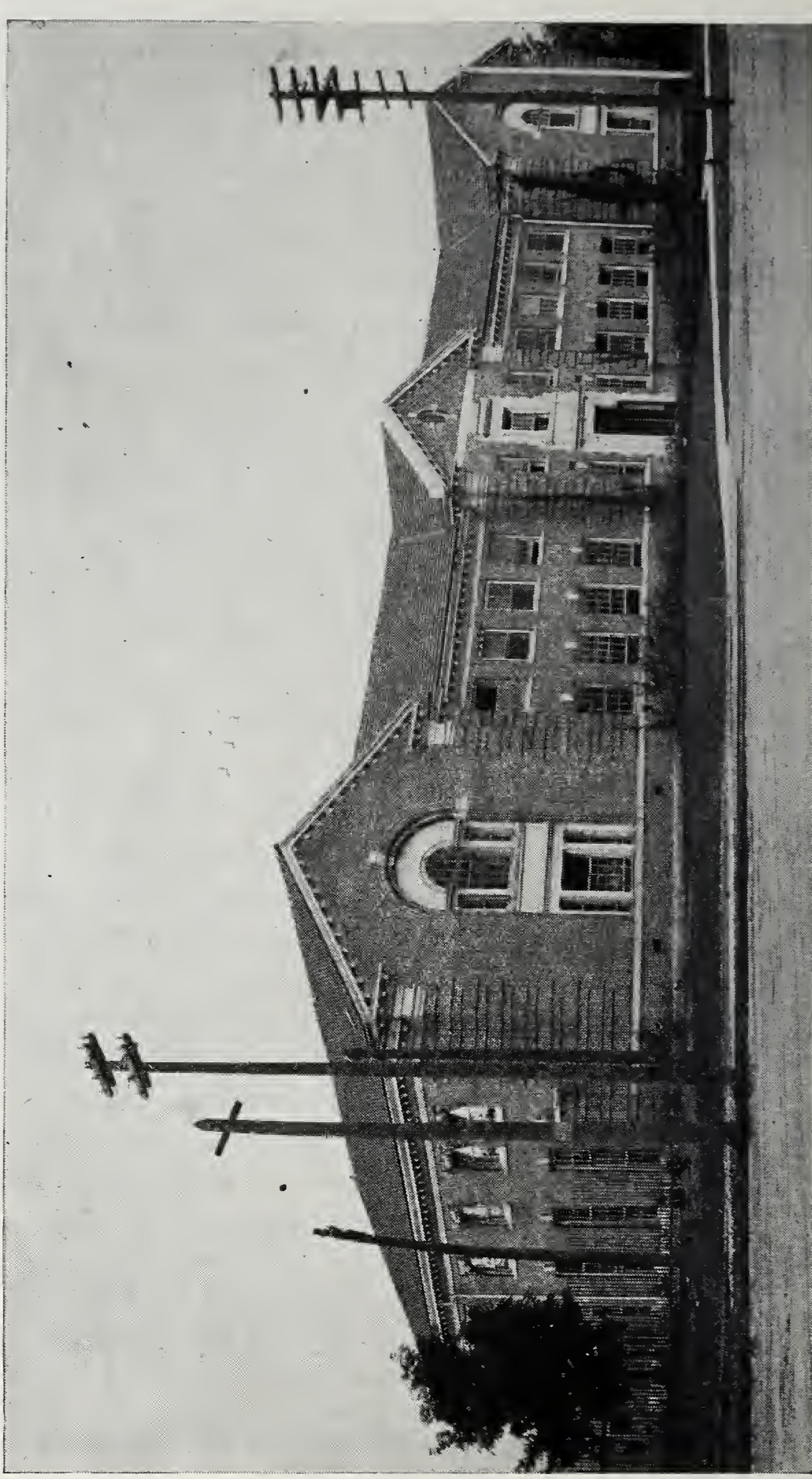


Fig. 98.—Forest Products Laboratory, Madison, Wisconsin. Operated by the Forest Service, U. S. Department of Agriculture, in Co-operation with the University of Wisconsin.

pose of these tests is to furnish engineers and architects with information which may be safely used in the design of timber structures, and to establish a correct basis for the grading of large timbers according to their mechanical properties.

Another series of tests is upon axles, spokes, cross-arms, poles, and other manufactured articles, for the purpose of demonstrating the fitness of various species and grades of material for these uses.

The fourth series of mechanical tests is for the purpose of studying the effect of preservative treatments, methods of seasoning, fireproofing, and similar processes, upon the properties of wood.

Physical Properties of Timber

A knowledge of the physical properties of wood is necessary in a large number of industries, and essential to the investigation of problems relating to the seasoning and preserving of timber. The physical properties of wood which are given especial attention at the Madison laboratory include density, shrinkage, heat conductivity, and ability to absorb water and other liquids. The seasoning of timber is probably the most important single step in the transformation of wood into usable form, and much material is annually lost because of poor seasoning methods. It is the purpose of the Service investigations to assist in the introduction of better methods of seasoning; and much has been accomplished, especially in the devising of a scientific dry-kiln.

Another important line of study is that of the relation of the structure of wood to its physical properties. This is a subject upon which there is far too little information. For example: Two pieces of white oak of apparently like quality, from adjacent trees, were received at Madison. So far as could be determined by all ordinary means, the two pieces should have been of equal strength; yet, when tested, one piece was found to be twice as strong as the other. There seemed to be no explanation for this peculiar result until sections of the two pieces of wood were put under the microscope, when it was quickly discovered that the fibers of the stronger piece were twice as long as the fibers of the weaker piece. This was a peculiarity of the growth of an individual tree, just as one boy of a family may be stronger than another, although the two are reared under exactly the same conditions.

Wood Preservation

The statisticians say that 200,000,000 cubic feet of wood were given preservative treatment in 1921; so there is no need to discuss the importance of a thorough understanding of timber-treating materials and the processes by which they are applied. The work of the Service laboratory along this line has already been very extensive, and recently it has gone a step further to include a study of methods by which wood may be rendered fireproof. Legislation against wood as a building

material in cities is becoming so general that it will be completely banished from many places where it is most useful and economical unless a method can be devised of making wood fireproof at reasonable cost.

Co-operation with the Public

It is the policy of the Forest Products Laboratory to secure as fully as possible the co-operation of the industries most directly concerned with the problems under investigation. In some cases, where the resulting work is of much value to the co-operating firm, a charge to cover part of the cost is made by the Service; in other cases, where the investigations are of an experimental nature and of general value, the services of the laboratory are entirely free. At all times, the laboratory furnishes, either by letter or through its publications, much useful information upon a wide variety of subjects.

Industrial Investigations

The Office of Forest Products of the Forest Service at Washington, D. C., which conducted the wood-using industry studies mentioned in this book, handles an annual census of forest products, makes intensive utilization studies of different woods, and in general is the clearing house for lumber production and consumption statistics and data on the uses of commercial woods.

The members of the Forest Service are of the highest type of public servants whom it is always a pleasure to meet or to correspond with. Any manufacturer of forest products or consumer of wood who has difficulty of any kind in the handling of his material, will find it worth while to lay his problems before the Forest Service experts. The chances are that he will get help, and get it promptly.

FOREST SERVICE PUBLICATIONS

Questions relating to the quantity, kind, and distribution of the timber supply of the United States, to the annual output of lumber and other forest products, to forest planting, to forest management, and to the National Forests, should be directed to the United States Forest Service, Washington, D. C. Such inquiries always receive prompt and courteous attention. Moreover, the following publications of special interest to the users of forest products can be obtained from the Government Printing Office at the nominal price mentioned.

Remittance should be made to the Superintendent of Documents, Washington, D. C., by postal money order, express order, or New York draft. If currency is sent, it will be at sender's risk.

Postage stamps, foreign money, uncertified checks, defaced or smooth coins, will positively not be accepted.

Management of Second Growth in Southern Appalachians. (Forest Circ. 118.) 5c.

Relation of Southern Appalachian Mountains to Inland Water Navigation. (Forest Circ. 143.) 5c.

Report of Secretary of Agriculture on Southern Appalachian and White Mountain Watersheds. 10c.

Arbor Day. (Dept. Circ. 8.) 5c.

Wood-Using Industries and National Forests of Arkansas. (Forest Bull. 106.) 5c.

Ashes, Their Characteristics and Management. (Agr. Bull. 299.) 25c.

Paper Birch in the Northeast. (Forest Circ. 163.) 5c.

Black Walnut, Its Growth and Management. (Agr. Bull. 933.) 20c.

Black Walnut; Forest Planting Leaflet. (Forest Circ. 88.) 5c.

Utilization of Black Walnut. (Agr. Bull. 909.) 30c.

Boxelder; Forest Planting Leaflet. (Forest Circ. 86.) 5c.

Cascade Mountains. Avalanches and Forest Cover in Northern Cascades. (Forest Circ. 173.) 5c.

Cascade National Forest—Fishing, Hunting, Camping. (Agr. Circ. 104.) 10c.

Cedar. Dry Rot of Incense Cedar. (Agr. Bull. 871.) 15c.

Incense Cedar. (Agr. Bull. 604.) 10c.

Chaparral; Studies in Dwarf Forests of Southern California. (Forest Bull. 85.) 15c.

Chestnut Bark Disease. (Agr. Yearbook—Separate 598.) 10c.

Chestnut in Southern Maryland. (Forest Bull. 53.) 10c.

Control of Chestnut Bark Disease. (Farmers' Bull. 467.) 5c.

Uses For Chestnut Timber Killed by Bark Disease. (Farmers' Bull. 582.) 5c.

Circassian Walnut. (Forest Circ. 212.) 5c.

Conifers of the Northern Rockies. (Education Bull. 53.) 5c.

How To Grow and Plant Conifers in Northeastern States. (Forest Bull. 76.) 10c.

Miscellaneous Conifers in the Rocky Mountain Region. (Agr. Bull. 680.) 20c.

Mistletoe Injury to Conifers in the Northwest. (Agr. Bull. 360.) 5c.

Forest Conservation for States in Southern Pine Region. (Agr. Bull. 364.) 5c.

Cooperage; Tight and Slack Cooperage Stock Production—1919. (14th Census, 1920.) 5c.

Cottonwood in Mississippi Valley. (Agr. Bull. 24.) 10c.
Cottonwood; Forest Planting Leaflet. (Forest Circ. 77.) 5c.
Forests of Crater Lake National Park. (Interior Dept.) 20c.
Crater National Forest, Its Resources and Their Conservation. (Forest Bull. 100.) 10c.
Creosote (Quantity and Character) in Well Preserved Timbers. (Forest Circ. 98.) 5c.
Relative Resistance of Various Hardwoods to Injection With Creosote. (Agr. Bull. 606.) 15c.
Prolonging Life of Crossties. (Forest Bull. 118.) 15c.
Seasoning and Preservative Treatment of Hemlock and Tamarack Cross-ties. (Forest Circ. 132.) 5c.
Cypress and Juniper Trees of Rocky Mountain Region. (Agr. Bull. 207.) 25c.
Cypress Bark Scale. (Agr. Bull. 838.) 10c.
Deschutes National Forest; Recreation Map for Mountain Travelers. 15c.
Forest Disease Surveys. (Agr. Bull. 658.) 10c.
Drying: Manual of Design and Installation of Forest Service Water Spray Dry Kiln. (Agr. Bull. 894.) 10c.
Seasoning of Wood. (Agr. Bull. 552.) 10c.
Theory of Drying and Its Application to the New Humidity Regulated and Recirculating Dry Kiln. (Agr. Bull. 509.) 5c.
Elm; Utilization of Elm. (Agr. Bull. 683.) 10c.
Eucalypts Cultivated in the United States. (Forest Bull. 87.) 10c.
Farm Forestry: Care and Improvement of the Farm Woods. (Farmers' Bull. 1177.) 5c.
Coöperative Marketing of Woodland Products. (Farmers' Bull. 1100.) 5c.
Emergency Fuel from the Farm Woodland. (Circ. 79.) 5c.
Farm Woodlot Problem. (Agr. Yearbook—Separate 651.) 10c.
Making Woodlands Profitable in the Southern States. (Farmers' Bull. 1071.) 5c.
Measuring and Marketing Farm Timber. (Farmers' Bull. 1210.) 5c.
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